THE MONONGAHELA BRIDGE.*

Rebuilding of the Monongahela Bridge, at Pittsburgh, Pa.

BY G. LINDENTHAL, M. AM. SOC. C.E.

The above work having been completed under my direction, I have the honor of presenting the following account of the same, having prepared it in the belief that it will interest members engaged in bridge construction.

Smithfield-street bridge, across the Monongahela river, connects Central Pittsburgh with South Pittsburgh. The need of a bridge at this point existed early in the history of the city. A ferry accommodated the travel over the river for a long time. In 1810 a charter for a bridge was obtained, and in 1816 the first structure, a covered wooden bridge of eight spans, 188 ft. each, was built. It consisted of wooden trusses, reinforced with wooden arches—for those days a remarkable engineering success.

The superstructure was burnt down in 1845, and was replaced with a wire suspension bridge, the engineer of which was the late Mr. John A. Roebling, M. Am. Soc. C.E., who had just finished a suspension aqueduct over the Allegheny river at Pittsburgh. The Smithfield-street bridge was Mr. Roebling's first road bridge.

On the old abutments and piers, after having been repaired, were erected cast-iron towers, which supported the cradled cables. The anchorages were put into the old abutments. Under each iron tower had been built up stone pedestals, 9 ft. square and 3 ft. thick.

The towers had the appearance of square truncated pyramids, 7½ ft. square at the base and 4 ft at the top, and 16 ft. high. The four-angle pedestals or columns of each tower were connected with cast-iron lattice frames, which filled the entire space on the road and river sides; on the two other sides openings were left for the side-walks, which led through the towers. The columns were surmounted by massive cast-iron top-pieces, in which the pendulums for the cables were hung with a slight inclination corresponding to the cradling of the cables. Each pair of towers was connected at the tops with a horizontal 12 to 16 wooden brace, which prevented the towers from being pulled towards each other by the cradled cables. The roadway was 20 ft. wide, having two car tracks.

On the outside of the cables were the sidewalks, 5 ft. wide. The hand-railing was formed of a wooden continuous Howe truss, 5 ft. high, bolted to the ends of the wooden floor-beams. These were 4 by 16, white pine, in pairs., 4 ft. apart. The planking for the roadway consisted of a lower 2 in. longitudinal pine planking, and upper 2 in. white oak planking as wearing surface. There was no horizontal or wind bracing, save the one derived from the stiffness of the plank floor. Across each pier, under the floor, extended three wooden beams, 12 in. by 12 in., 40 ft long, and diagonally braced from the piers below; they were acting as cantilevers, giving some rigidity to the suspended platform near the towers. The cables, 4½ in. diameter, each contained 750 wires of No. 10 Birmingham gauge. The wires were laid parallel to axis of cable, and closely wrapped with No. 14 annealed wire.

The travel over the bridge, on which toll is collected, was of the heaviest kind, and is steadily increasing in bulk and weight. The suspension-bridge had become very shaky and loose; its continuous swaying and creaking had created anxiety in the public mind; it had evidently outlived its usefulness. A new bridge was decided upon in the summer of 1880.

The Bridge Company at that time was in favor of another suspension bridge, but with larger spans on a higher grade, and adopted a plan proposing two channel spans of 360 ft. each, and two shore spans of 180 ft. each. A contract for such a bridge was made, and the building of the same commenced the same summer, under the superintendence of Charles Davis, M. Am. Soc. C. E. The foundations for the channel piers were put in first, and the piers themselves built up to an average height of 10 ft. The winter season stopped any further work in that year (1880).

In February, 1881, the Bridge Company was reorganized, and the new managers desired a different bridge. It should not be subject to undulations, and should be capable of enduring the continually increasing traffic without limitation of load or speed.

At this time the writer was invited for consultation and to suggest suitable changes in the plans, which should provide for a moving of the bridge by adding another roadway or track, should this ever become necessary in the future. After having submitted such plans, they were accepted and the writer was engaged to carry them out. This plan proposed to utilize the foundations and piers which had been commenced They were to be built upon, without any offsets, to a width on top of 56 ft.

As the width of the superstructure may ultimately reach 64 ft., or 8 ft. wider than the piers, it became necessary to let the sidewalks project over the masonry. The present width is 48 ft. on the channel spans; the room on the piers for widening the bridge was left on the up stream side. For the channel spans Pauli trusses were proposed, 25 ft. 8 in. apart, centre to centre, and the centre line of the new floor (of 48 ft. width) was shifted down stream 8 ft. 2 in. from the centre line of the old bridge. The sidewalk on the up stream side was proposed to be detachable, so that the floor may be widened and the sidewalks again connected to it.

For the approaches to the channel spans, plate girder deck spans, on lighter masonry piers, were proposed. This arrangement allows of increasing the width of the bridge by simply adding more plate girders to each span on the piers which are long enough for that purpose. Being a deck bridge, it afforded an unobscured entrance view to the channel spans, the trusses of which were to rest on ornamental towers, giving to the superstructure an architectural appearance of st.ength and stability.

The shifting of centre line of new floor 8 ft. 2 in. down stream from the centre line of the old bridge allowed of erection of the new superstructure without stopping travel on the bridge, in a manner described more in detail below.

The Pauli truss type commended itself for the channel spans in this instance, for several reasons:

1. The pleasing appearance (for a city bridge) in comparison with the ordinary parallel chord truss.

2. The fact that the trusses could be made high in the middle (without detriment to their stability in case of high winds), thereby reducing the chord strains and chord sections. In connection with the light and slender web-members, it permitted of an economy in the trusses of over 9 per cent., as compared with parallel chord trusses (with inclined end posts) of same height (50 ft.) The deflection and vibration of high trusses is small and their rigidity great.

3. The bottom chord or cable is exposed to the sun's rays as much as any other truss-member; therefore unequal temperature effects in the trusses are avoided. The covered floor construction is independent of the trusses as to temperature effects.

4. The floor had to be cambered 18 in. in each 360 ft. span to agree with the general grade of the new bridge. A straight bottom chord with a rise of 18 in. in 360 ft. was undesirable.

At first it was proposed to build the new structure 10 ft. higher at highest point than the old bridge. But the river men, in the interests of navigation, demanded the structure to be at least 20 ft. higher, or 57 ft. above low water mark, to which the Bridge Company objected, on the ground that the additional 5 ft. height would injure travel over the bridge much more, by reason of a steep grade at the Pittsburg end, than it would benefit navigation.

There is no statute prescribing the height of bridges over the Monongahela River. The case was taken to a court of equity, and argued there by lawyers *pro* and *contra*, resulting in a preliminary injunction against the Bridge Company building the bridge lower than 20 ft. To continue the litigation would have required much time. After a suspension of work at the bridge for ten months the Bridge Company decided to accede to the demands of the river men.

The following is a description of the material and methods used in the construction of the bridge:

Masonry.—Consists of a grey, hard, and durable sandstone, free from admixtures of clay or iron oxide particles. It was quarried near Homewood, Pa., on the Pittsburg and Lake Erie Railroad, where it is found in large blocks of 100 to 500 cubic yards, without any stripping. The masonry is rock-faced, with drafts 1 in. wide all around the face of the stones, which are in courses of alternate headers and stretchers.

The dimensions of the stone are 24 in. to 16 in. in thickness, 7 ft. to 4 ft. in length, 3 ft. to 1¾ ft. in width, with beds and joints dressed regular and true. The backing for the abutments and wing walls consisted of regular-shaped stones, with dressed beds; for the heart of the piers concrete filling was used. It was applied in layers of 12 in. thick. It proved superior in every way to ordinary stone backing. Iron clamps bind the stones in the pier heads in every course.

The use of spalls was not permitted in any part of the masonry. All spaces between stones were filled with concrete, rammed with iron rammers, making every course absolutely water-tight. Great attention was given to the bond. The stone blocks were laid in alternate header and stretcher courses, which made the coincidence of stone joints in the heart of the pier impossible. In this way each stone is bonded in every direction. The concrete backing, after setting, was very hard and tough; it adhered to the stones with great tenacity, and, in fact, made the piers monolithic.

In the execution of the work care was taken to wet every stone immediately before setting. When laid in position the stone was settled by repeated blows of a heavy wooden ram. Any stone breaking under this operation was removed.

The face joints of the finished masonry were cleaned out to a depth of 1 in., and thoroughly moistened, and caulked with Portland cement and sand mortar mixed one to one.

For all face masonry exposed to the weather American Portland cement was used for the mortar; for concrete backing and foundations, Rosendale cement was ordinarily used.

All cements were required to be so finely ground that 90 per cent. of the whole would pass through a sieve of fifty meshes to the lineal inch. Tests as to its tensile strength were conducted on a Fairbanks testing machine with moulded briquettes of pure cement.

Rosendale cement made of a stiff paste, having been one day in water and one day in the air, at an even average temperature of 70 deg. Fahr. (in a room), were tested to show a tensile strength of at least 40 lb. per square inch.

American Portland cement briquettes, under the same conditions, were tested to show a tensile strength of at least 80 lb. per square inch.

Similar briquettes, after having been four days in water and one day in the air, at the above average temperature, were tested for a tensile strength of 60 lb. per square inch for Rosendale cements, and 150 lb. for American Portland cement.

The concrete used throughout the work was composed of two parts of sound broken stone, passing through a 3 in. ring; two parts of clean gravel from the size of a pea to 2 in. in diameter; two parts of washed river sand; one part of Rosendale cement of accepted quality.

For concrete under water two parts of cement were used to allow for waste by washing in depositing it under water. With a little care in the operation the loss, however, was insignificant. The stone, gravel, and sand were first mixed on a board platform, then the cement added, and the whole mass thoroughly rehandled in a dry state. Water was then added in barely sufficient quantity to reduce the whole mass, by lively and severe shovelling to a stiff mortar. This was put immediately in place in layers of not over 12 in. thick, and thoroughly rammed with iron rammers about 5 in. square and weighing 36 lb., until the mass flushed uniformly over the whole surface.

For depositing the concrete under water for the pier foundations square wooden troughs were used, reaching almost down to the bottom, and the concrete dumped in and raked even with iron rakes having long handles. The running out of the concrete was prevented by sheet piling. When a change in the masonry of pier No. 4 required the removal of a few stones, they were found to form with the concrete backing one solid mass, which had to be rent asunder with steel wedges and sledge-hammers, and would sometimes break through the stone rather than through the concrete.

Openings or slots for one car track were left in the new abutments and piers to accommodate travel on the old bridge.

The pier posts of the channel spans on the down-stream side have their bearing near to the pier ends, and to prevent cracking of the channel piers, or uneven settlement after the superstructure should be in place, rivetted iron anchors were walled into the top of piers Nos. 2, 3, and 4. The coping on the piers consisting of two projecting courses of cut stone, was nearly all in place for a grade 15 ft. higher than the old bridge, at the time of the dispute with the river men. When the height of the piers was increased to suit a grade 20 ft. higher than the old bridge, the additional masonry was built on top of the coping in the form of pedestals of cut stone.

After the erection of the superstructure had so far progressed that travel could be turned on to one track on the new bridge, the old bridge was abandoned, and the gaps and openings in the masonry of the new abutments and piers successively walled in and closed. In this wise it was possible to complete the masonry work without stopping travel on the old or new bridge.

Superstructure.—The roadway is at present 22 ft. 10 in. wide in the clear, and two sidewalks each 10 ft in the clear. The full width of the bridge on the deck spans of approaches is 43 ft. 6 in., and on the channel spans, which are through spans 48 ft.

The bridge can be widened out, if ever required, to 64 ft. This made it necessary to erect the present superstructure nearer to the down-stream end of the piers. It detracts much from the appearance of the bridge, which is unsymmetrical at present. It was important not to stop travel during the rebuilding of the bridge. Passengers and freights from and to the Pittsburg and Lake Erie Railroad must pass over it. Besides there is a heavy traffic in coke, iron, and other mill material, which would have been compelled to take a long roundabout way. The construction of the superstructure had to be arranged to allow of the erection first of one track and then of the other.

If the new bridge had really been built 15 ft. instead of 20 ft. higher than the old one, there would not have been left height enough near the ends of the channel spans for teams to pass under on the old bridge. It was therefore intended to erect the channel spans about 5 ft. higher than their proper grade, and to complete the floor and tracks of the same.

The pier posts would have temporarily rested on sand jacks by means of which both spans, weighing about 1,600 tons when completed, could have been simultaneously lowered in a few hours to their proper grade. One track and sidewalk, on the plate girder approaches on the down-stream side, would have been meanwhile prepared for use. In this way travel would have been interrupted only for one day. But this operation became unnecessary when the new grade was raised 20 ft. above the old bridge.

Channel Spans.—It was found that the use of steel, in the trusses at least, would prove economical as com-

* Paper read before the American Society of Civil Engineers, at the Annual Convention, St. Paul, Minn., June 20th, 1883.

pared with wrought-iron. The saving based on the prices at that time was over $21,600.

The Pauli trusses were designed with an uneven number of panels, namely, thirteen, in order to get two tangential points of attachment for each truss to the floor construction, thereby securing greater longitudinal and transverse rigidity of the entire bridge frame. Roller bearings for pier posts were avoided; the middle posts, supporting two truss ends each, have a fixed and square bearing on heavy pedestal castings on the pier. Each end post has a bearing on a 6 in. steel pin in a cast-iron pedestal on which it can rock. It is probable that very little movement takes place on account of friction on the pin, and that the posts would bend or spring. The resulting bending-movements on the end posts have been considered in proportioning them.

The projected length, 37 ft. 7⅝ in., of all panels being alike, it follows that the lengths of chords in a curved line are unlike, and if the curve were a circle or a parabola, then the angles formed by the straight chord sections would also be all unlike. For practical reasons it is desirable to have these angles all alike, so as to have only one template for the bevelled joints. This condition would prescribe the character of the curve, in this instance a sine-curve. The difference in curvature between a sine-curve and arc of a circle was found to be small (2½ in). The difference in the bevel joints was inappreciable (2/10 in.) Therefore, a true arc line was then assumed for the chords to facilitate other calculations.

The vertical web-members are in tension from the dead load or from a uniformly distributed live load. They will sustain compression strains only from an uneven distributed by load. Near the centre of truss they are long and slender, requiring intermediate bracing which was placed at half the truss height for the entire length of trusses.

The suspenders from trusses to floor, which were all stiffened to prevent vibration, were not made adjustable; their exact lengths were calculated to give the required camber of 18 in. to the floor construction. The truss camber was obtained by shortening the lower and lengthening the upper cord members ⅞ in., so that after erection it amounted to 2 in.

All diagonal bars were made adjustable and single; they are strained from partial loads only. The trusses were adjusted to their proper shape by means of these ties, which received a slight initial strain. The top and bottom chords, pier-posts, diagonal ties, and pins are of steel; all other parts are of wrought-iron with steel rivets. The calculated sections of the vertical web-members for steel were so light that for practical reasons they were all made of wrought-iron and of the same section.

Quality of Steel Used.—Every heat of steel was tested and its quality determined before any more work was done to it. For the compression members and pins, the steel was required to stand the following tests on specimen bars ⅝ in. in diameter.

Elastic limit: 50,000 to 55,000 lb. per square inch.

Ultimate strength: 80,000 to 90,000 lb. per square inch.

Elongation in 8 in.: Minimum 12 per cent.

Reduction of area at fracture: Minimum 20 per cent.

Cold bending: 180 deg. around its own diameter without crack.

Cold punching of holes in flat 3 in. by ⅝ in. bars: ⅞ in. from the edge without crack or distension of metal.

All specimens and shapes were required to be finished at nearly the same heat, as it was observed that rods finished at a lower heat would give higher tension results than samples of same steel finished at a higher heat.

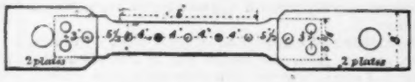
The Andrew Kloman firm in Pittsburg had contracted to procure the steel and to furnish the steel shapes. The intention was to use Bessemer steel for the compression members; a large lot of Bessemer steel was tested, but few samples were found to stand the required tests. The difficulty seemed to consist in controlling the uniformity of the steel within close limits for quality and strength. After awhile the attempt was given up and open hearth steel was substituted. No trouble was then experienced in getting a uniform grade of steel of prescribed quality.

The top chord sections consist of four leaves, which were originally designed to be each a 20 in. steel plate with 4 in. by 4 in. angles for flanges. In ordering the steel it was discovered that enough plates of that width could not be procured in the required time. Therefore, the chord sections were changed to 10 in. and 12 in. steel plates, with 4 in. by 4 in. angles, composed as shown in the drawings.

Notwithstanding the great care used, the finished plates and angles were by no means a uniform product. According as they in rolling were finished at a higher or lower heat, they would have different degrees of hardness. Steel plates and angles finished at a lower heat had a smooth surface, and the noise of punching them resembled pistol shots, while plates finished at a higher heat had a rougher surface, and there was hardly more resistance to punching than in wrought-iron. The specifications for rivetted steel work provided that the punched rivet holes ⅞ in. in diameter, should, in the assembled parts be enlarged to 1 in. diameter by reaming. The time for the delivery of the steel work growing short, the question was considered whether the reaming of the holes could be avoided, to hasten the completion of the work at the shops. Messrs. Kellogg and Maurice, in Athens, Pa., had the contract for this part of the work.

To that end the following experiments were made:

Ten specimens were cut from the same steel plate ¾ in. thick; one specimen was tested to ascertain the tensile strength of the steel in the specimen. The nine other specimens, all alike in form, were prepared as shown in the sketch, for the purpose of ascertaining the effect of punching holes, of punching and reaming, and of drilling. The tests were expected to show the amount of reaming required, and whether any annealing effects from the hot rivet on the injured steel around the punched hole could be observed.



9 specimen bars 4 in. × ¾ in. like this.
Holes 1 in. diameter, net section of bar 0.75 square inches.

—	—	—	Strain per Sq. In.
			lb.
1. Plain specimen 3 in. by ¾ in.	Without holes	Broke with	89,730
2. 2 holes punched ⅞ in. in diameter. 3 holes punched ⅞ in. reamed to 1 in.	No rivets in holes	Broke in punched hole with	72,000
3. Prepared as No. 2	No rivets in holes	Broke in punched hole with	63,870
4. Prepared as Nos. 2 and 3	Rivets in all holes	Broke through punched hole with	84,000
5. Two holes punched ⅞ in. in diameter. 3 holes punched 1 1/16 in., reamed to 1 in.	No rivets	Broke in punched hole with	72,000
6. Prepared as No. 5	Rivets in all holes	Broke in punched hole with	55,200
7. Prepared as Nos. 5 and 6	Rivets in all holes	Broke in punched hole with	83,320
8. All holes drilled 1 in. in diameter	No rivets	Broke in hole with	79,330
9. 2 holes punched ⅞ in., reamed to 1 in. 3 holes punched 1 1/16 in., reamed to 1 in.	No rivets	Broke in hole with	64,400
10. Prepared as No. 9	Rivets in all holes	Broke in hole with	83,320

The conclusion from these tests was that the injured steel (of the quality used in this instance) around the punched hole was in part restored by annealing in contact with the hot rivets, the size of which was large in proportion to the thickness of steel plates and angles as used in the chords. The reaming of the punched holes to a greater extent than to make the rivet holes smooth and straight was therefore dispensed with, and a reduction in the price for the finished work agreed upon.

The steel pins are 6 in., 5¼ in., 4 in. and 3¾ in. in diameter. The same quality of steel as for the compression members was used for them; they were forged from solid steel billets, and turned to size. No appreciable difference in the hardness of the metal in the pins was observed.

For tension members and rivets, the steel was required to stand the following tests on specimen bars ⅝ in. in diameter:

Elastic limit, 45,000 lb. to 50,000 lb. per square inch.

Ultimate strength, 70,000 lb. to 80,000 lb. per square inch.

Elongation in 8 in., minimum 18 per cent.

Reduction of area at fracture, minimum 30 per cent.

Cold bending, to a loop 360 deg. around its own diameter without crack.

Cold punching in 3 in. by ⅝ in. bars of 1 in. rivet holes; ⅞ in. from the edge, without crack or distension of metal.

Open hearth steel, of the above and uniform quality, was obtained without trouble.

The eye-bars were made by the Kloman process, *i. e.*, the bars were rolled from billets between reversible and adjustable rolls, in such manner as to leave the ends thicker than the bar. The ends were then spread and forged to the proper shape of the eye, under a steam hammer. The heaviest steel bars for this bridge were 28 ft. 6⅝ in. long centre to centre of eyes, and 1⅛ in. thick. All steel billets and all steel bars required very close inspection for flaws, the detection of which was sometimes difficult.

It has been stated that, for the detection of flaws in steel or iron, a magnetic needle had been used with success, though the manner of its use the writer has not heard stated. A device for the certain discovery of flaws in steel bars is certainly needed. Where the solid metal sections are proportioned very economically to the work they have to do, flaws are a source of great danger, especially in attenuated steel structures; flaws in wrought-iron are more likely to happen in the direction of the fibre, but in steel they can as well happen crosswise to the direction of the tension strain as any other way.

Three steel bars, 9 ft. long between centres of eyes and 4 in. by 1⅛ in. in section were tested to ascertain the effect, if any, of annealing the finished bars.

The results were as follows:

—	Bar A. Annealed.		Bar B. Not Annealed.		Bar C. Not Annealed.	
	Eye.	Eye.	Eye.	Eye.	Eye.	Eye.
Diameter of eye....in.	9	9	9⅛	9 ⅛	10	9
Least cross section of eye.....sq. in.	5.72	5.82	5.83	5.72	6.83	5.77
Excess of metal in eye over bar....per cent.	29.4	31.7	38.1	35.5	57.7	33.2
Reduction of area in eye at pin hole..... per cent.	7.9	3.6	3	3.2	3	3
Elongation of pin-hole .....in.	0.4	0.72	0.65	0.44	0.83	0.4
Average section of bar sq. in.	4.42		4.22		4.33	
Averaged reduced area after test..sq. in	3.96		3.97		3.89	
Reduction in per cents 10			5.1		10	
" at fracture per cent.	43.87		37.5		37.55	
Elongation of whole bar..... per cent.	10.5		10.3		11.1	
Elongation for 12 in. near fracture..... per cent.	24.6		23.2		22.1	
Elastic limit per sq. in. .....lb.	43,140		45,360		40,940	
Ultimate strength..lb.	74,310		78,180		73,760	

All pin-holes were 3⅛ in. in diameter.

The pin-hole in one eye of bar C was bored ¼ in. out of centre line of bar, and accounts for its lower ultimate and elastic limit.

A specimen from the same heat of steel, of which the above bars were made, showed on a ¾ in. round:

Elastic limit,	46,389 lb. per square inch.
Ultimate limit.	78,898 "
Elongat on in 8 in.,	18.0 per cent.
Reduction,	30.2 "

The net section of the head through the pin-holes for all eye-bars being at least 50 per cent more than the bars, and the good effects from annealing being doubtful in the above tests, it was not thought necessary to anneal the steel bars.

For steel rivets, the above quality of tension steel proved very suitable. The rivets were tough and tenacious. It was, however, observed that the manufactured rivet-heads would easily break off with few blows, the fracture in each instance showing a fine granulated appearance. Rivet heads, however, made by hand or rivetting machine were very tough, and could not be broken off; they had to be cut off. The cause for the brittle rivet heads was supposed to be the upsetting by blows, in forming the head at a high heat in dies, producing sharp corners under the rivet head and around the rivet stem.

Plate Girder Spans.—There are six plate girders in each span beneath the flooring, namely, one girder under each rail and one girder under each sidewalk, which is detachable on the up-stream side.

This arrangement was chosen to admit of the erection first of the new down-stream street track, which came to lie sideways of, but on a higher grade than, the down-stream track of the old bridge. To this track, travel was confined during erection. Plate girders were chosen for the reason that for the limited depth of floor (for a grade 15 ft. higher than old bridge, as at first contemplated), it gave a more rigid construction than open girders at low depth. It was also more convenient to work into them, and get rid of a lot of wrought-iron which was on hand, and was left over from orders for the suspension bridge originally intended to be built.

Could the writer have forseen that the new grade would be 20 ft. higher than the old bridge, the deck spans of the approaches would have been made of two open girders of greater depth, in a manner that would have been made of two open girders of greater depth, in a manner that would have admitted of finishing both tracks on them at the same time. This would have been also more economical. As it was, the plate girders were nearly finished when the change in grade was made.

For all wrought-iron work in the bridge the quality of iron was required to be equal to that of standard bridge iron.

Steel rivets were used for all wrought-iron bridge members and girders.

Removal of Old and Erection of New Bridge.—The new north abutment wall was located 40 ft. back of the old one. In preparing the foundation for the same, it was necessary to remove the anchorage of the old cables, and to construct, temporarily, two anchor chains attached to the second pair of old towers. Previous to this, wrought iron anchors had been imbedded into the foundation of new pier No. 1, which had been built up to obtain the requisite weight for the temporary anchorage.

These anchor chains were composed of steel eye-bars, which were on hand from the intended suspension bridge. Each chain was made adjustable in length by means of a transverse screw rod, and four sets of eye-bars, forming a funicular machine. The chain could thereby be shortened with comparatively little power To the cable the chain bars were attached by means of two wrought-iron plates. Between these plates were

cast-iron friction clutches holding the cable, and pressed and held together with bolts passing through the plates. These were attached to the cable as near to the towers as possible. To prevent slipping of the clutches on the cable, the wire wrapping was removed, and the spikes driven through the cable wires behind the clutches.

The transfer of the anchorage was done without mishap, while travel, as usual, was going over the old bridge on both tracks. The pull per anchor chain was at times 160 tons.

Under the first north span of the old bridge, false works had been built, which after the transfer of the anchorage, supported the whole roadway, and at the same time served for the erection of the iron girders for the new bridge. No other part of the old bridge was removed till after the erection of the new channel spans

In the false works for the latter, an opening, 100 ft. wide, near the Pittsburgh end was left for navigation, and temporarily bridged over with wooden Howe trusses. The false works were further so arranged as to clear one track on the old bridge, on which the team-travel moved in squads in alternate directions.

To prevent accidents from anything falling from above on pedestrians or teams below, the false works were covered with a platform of planks, which were afterwards used for the new floor. The upper staging was built up on the outside of, and to half the height of, the trusses to be erected; at that height a traveling derrick, 30 ft. high, moved on a track of iron rails. All material for the channel spans was lifted (by a hoisting engine near the south Pittsburgh end) to the platform, on which a temporary track was laid, and all materia transferred on push-cars.

With another hoisting engine, conveniently located on the up-stream end of pier No. 3, the material for both spans could be handled and put in place without moving the engines.

The Pittsburgh span was erected first. After the pier posts were put in position, the bottom chords and connecting web-members were put in place. The top chord sections, weighing from 7 to 9 tons, were picked up and placed on the verticals, one after the other, from each end in each truss. For closing the top chord, the two middle chord sections were raised at one end till they met, and then sprung into line by pulling down these ends towards the bottom chord with block and tackle acting as a funicular machine.

The false works of the Pittsburgh spans had settled more than was anticipated. Before it was possible to close the top chords, the different panel points had to be jacked up 2 in. to 6 in. No such trouble was experienced with the other span.

During the erection of the channel spans, no little anxiety existed at the possibility of an accident from some heavy weight dropping to the platform and breaking through to the constantly crowded old bridge below. Fortunately, the work was completed without such accident, but there were two casualties, which both resulted luckily. One man fell from a height of 80 ft. into the river, but was picked up and next morning was at work. Another man fell from a height of 50 ft. into shallow water; he was able to report for work after two days.

The iron floor construction was suspended to the trusses after these were swung.

The detail of connections in the Pauli trusses being simple, the erection of the steel and iron work went off smoothly, and with no more expense than in parallel chord trusses. It commenced in the middle of September, 1882, and was completed December 31, 1882.

To the new iron floor construction the old bridge floor was temporarily suspended with iron rods on wooden blocks, laid crosswise on the bottom flanges of the stringers.

The towers of the old bridge, on the down-stream side, were in the way of the erection of the iron plate girders at the south end of the bridge. These down-stream towers were removed first, together with the cable they supported. The old bridge floor, where it was not suspended from the new bridge, was held up on wooden trestles.

Three plate girders in each span, supporting the down-stream track and sidewalk, equal to half the width of the new bridge, were put into position, and the paving for one car track finished for the entire length of the bridge, without interrupting travel on the old bridge below.

Temporary wooden trestle approaches, with plank floors for one track, were built at both abutments, because the filling in would have interferred with travel on the old bridge. All this work was much retarded by a stormy and severe winter. Travel was turned over the new bridge on the down-stream track on March 10 1883.

During a high water, February 22, 1883, a heavy mass of ice came down the river on a swift current, and tore away a part of the false works supporting the old bridge in a place where it was not suspended from the new one. The old bridge was then in danger of falling into the river; but by promptly suspending the old floor to the new one, first with ropes and chains, and then with iron rods, the old bridge, after one and a half day's interruption, was again safe. This was the only interruption of travel throughout the whole work.

After travel was turned on the new bridge, the gaps and openings in the abutments and piers were walled in, as stated before. The remaining old towers, cables, and bridge floor were removed, and the up-stream half of the plate girder approaches completed.

This was done by placing in position the remaining three plate girders in each span, and the iron columns (supporting the girders near the abutments). At the same time the erection of the hand-railing and of the ornamental cast-iron tower progressed. The adjustment nuts of the diagonal ties in the channel spans were covered with ornamental castings, which prevent tampering with sleeve nuts.

The filling in and regrading of the approaches at both ends, and the building of the toll-houses and bridge office, were completed simultaneously with the superstructure.

The Flooring of Roadway and Sidewalk.—This consists of preserved wood, namely gum-wood and white pine preserved by the zinc-tannin process. On both the roadway and sidewalks the bottom planking distributes the weight on the iron and girders, so that the top sheeting or paving forms merely the wearing surface.

To the top of iron floor girders are bolted wooden bolsters, to which is spiked the bottom cross-planking, 3 in. thick for the roadway, and 2 in. thick for the sidewalks.

No provision is made to carry off the water sideways. The grade of the bridge is sufficient to carry off all surface water lengthwise. Besides, the durability of the preserved gum-wood is increased by keeping the floor moist (by sprinkling during the dry season).

The space between the track rails and in the middle of bridge is paved with preserved gum-wood blocks 3 in. thick and 3 in. high, laid with ¼-in. strips between.

Every paving block is fastened down to the bottom planking with diagonal spikes. The paving blocks for the tracks rest on a 1-in. longitudinal sheeting of preserved white pine, which serves to distribute lengthwise any uneven pressure to the cross planking beneath. The joints between paving blocks were filled with a hot mixture of tar, pitch, resin, lard, lime, and sand in such proportions as to run freely from the ladle.

The space between the tracks and sidewalks is covered with a lengthwise top planking 3 in. thick.

The sidewalks are 9 in. higher than the roadway. The wearing surface consists of white pine, 1 in. thick, on the bottom planking of gum-wood, 2 in. thick. In the curb are openings 30 in. long, and on the average 3 ft. apart for cleaning the roadway of mud and snow. Under the sidewalk, on the down stream side, extends a box with a movable cover, the entire length of the bridge. This contains the water and gas pipes and telegraph cables. Every 150 ft. are covered openings for hose attachment, provided for sprinkling the floor and for use during a fire.

A small fire occurred in April, 1882. It originated on the old bridge, and scorched the floor of the new bridge near the southern end. It showed the necessity of guarding against fire on the new bridge. All wooden flooring is to be protected by a paint of quicklime and glue water, and all crevices and joints in the wooden floor to be filled with it.

For the preservation of the lumber by the zinc-tannin process, the specifications stipulated that steaming in the curing cylinder should continue at 18 lb. pressure for four and a half hours; the vacuum should not be more than 2 lb. per square inch. Gum-wood should absorb 25 per cent., and white pine 12½ per cent. of the antiseptic solution under a pressure of 30 lb. per square inch. The solution is to be five parts (in bulk) of chloride of zinc to ninety-five parts of water. The lumber was to be left in it till each cubic ft. of gum-wood had absorbed 1¾ gallons, and each cubic ft. of white pine 1.05 gallons of the antiseptic. After this a solution of tannin was forced into the cylinder, and the lumber kept immersed in it for three hours, under 80 lb. pressure.

Borings, from the end of a stick which were analyzed, contained 0.379 per cent. metallic zinc in weight, equivalent to 0.789 per cent. of zinc chloride. This was rather a high showing, as 0.5 per cent. of zinc chloride was all that was expected.

Borings taken from the middle of a stick 26 ft. long 12 in. by 6 in., were found, on analysis, to contain 0.125 per cent. of zinc chloride, or only one-quarter of the amount intended to be injected; it is doubtful whether in long sticks the desired percentage can be attained without very materially increasing the strength of the solution, which again would probably increase the percentage at the ends to such an extent as to render the lumber brittle after awhile.

The borings were from freshly treated lumber. It is probable that the percentage is gradually increased to a limited extent in the heart of a long stick, owing to interchange of the solution by capillary attraction along the grain of the wood. The real antiseptic substance is the zinc chloride, while the tannin serves only to increase the adhesion of the precipitate to the wood fibres.

Care was required in the inspection of the lumber before treatment. Sap, loose knots, cracks, windshakes, are of course as much a defect in treated as in untreated lumber. Any unsound, weak or soft wood will not be improved by the treatment, which aims merely to make the lumber more durable, by preventing rotting. It may be added that lumber, treated by the zinc-tannin process, will not loose anything in its value as a combustible, as the experience with the fire at Monongahela Bridge proved.

The track rails on the bridge are 12 in. wide, and composed of flat bars 7 by ⅜ in., 30 ft. long, rivetted together with countersunk steel rivets to a section, as shown in drawing.

Splice-plates 12 in. by ⅜ in., 2 ft. long under the joints, and ¾ in. round spikes, with conical heads, countersunk to the full thickness of the rail (⅜ in.), so that the spikes may hold down the rail, no matter how thin it may have worn.

The Ornamental Towers.—The ornamental towers are built of cast-iron, the roofs being of wrought-iron; they support merely their own weight; they incase the steel posts, which, to the eye, would seem very slender supports, and would appear out of proportion in comparison with the heavy piers and high trusses. The end posts can rock inside of the towers, which are not in any way connected with them. Where the trusses pass through the towers, room is left for expansion from temperature changes.

The architecture of the towers is so planned, and the composing parts so arranged, that the portals may be widened out to suit the entrance to a wider bridge, should it be required.

Painting.—Besides painting the metal with raw linseed oil at the mills, and iron oxide paint at the bridge shops, two coats of white lead paint were applied to the erected steel and iron work. The white lead paint was used without any dryer, and mixed with boiled linseed oil only. All joints and crevices, where water might collect, were puttied all around and raw linseed oil poured in, as much as they would hold.

As the erection took place mostly in inclement weather, the shop paint came off in many places by dragging the piece through slush and mud, which, especially at Pittsburgh, rusts iron rapidly.

Rusty places were coated with a thin lime paste, which, after drying, was scrubbed off with wire brushes and freshly painted.

All iron work under the flooring has been painted brown; all iron and steel work above the flooring is blue. The towers have a stone color.

Loads and Unit Strains.—Beginning from the north end there are:

1. One 40-ft. span, six equal plate-girders, proportioned for a live load of 10,800 pounds per lineal foot of bridge.

2. One 81-ft. span, six equal plate-girders, proportioned for a live load of 9,000 pounds per lineal foot of bridge.

3. One 87-ft. span, six equal plate-girders, proportioned for a live load of 9,000 pounds per lineal foot of bridge.

4 and 5. Two channel spans, 360 ft. each, two equal Pauli trusses of steel and floor construction of iron, proportioned for a live load of 4,500 pounds per lineal foot of bridge and, in addition, a concentrated load of 40 tons on a 20-ft. wheel base for each track; of these loads the sidewalks were assumed to carry 100 pounds per square foot.

6. One span, 88 ft. 3 in., six equal plate-girders.

7. One span, 84 ft. 9 in., six equal plate-girders.

8 and 9. Two spans, 60 ft. each, six equal plate-girders in each.

All of these plate-girder spans proportioned for 9,000 pounds live load per lineal foot of bridge.

The wind truss and lateral bracing under the floor is proportioned for a wind force of 400 lb. per lineal foot of bridge.

The above live loads, in addition to the load of the superstructure in the different spans, produce no greater strains per square inch of useful metal areas than:

For Iron.—8,000 lb. in compression flanges of all plate-girders, floor beams, stringers, etc.; 9,000 lb. in tension flanges of all plate-girders, floor beams, stringers, etc.; 8,000 lb. tension in suspenders and hangers of channel spans; 4,000 lb. shear in iron web plates; 12,500 lb. bearing strain on iron in rivet and pin-holes.

For Steel.—9,800 lb. to 13,200 lb. in compression members; 15,000 lb. in steel eye-bars; 10,000 lb. shears on steel rivets and steel pins; 20,000 fibre strain on steel rivets and pins from bending moment; 18,000 lb. bearing strain on steel in rivet and pin-holes.

The following quantities of material were consumed in the construction of the Monongahela Bridge:

Foundations:	
Lumber	394,000 ft. B.M.
Piles	10,800 lineal ft.
Concrete	1,380 cub. yds.
Iron	32 tons
Stone masonry	10,500 cub yds.
Superstructure:	
Iron	1,070 tons
Steel	740 "
Cast-iron of towers, pedestals, etc.	196 "
Preserved lumber for floor	358,000 ft. B.M.
Steel rails	134 tons
Hand railing, 2,980 lineal feet	120,200 lb.
Approaches:	
Filling	10,000 cub. yds.
Sidewalk pavements	1,400 sq. yds.
Street pavements	2,300

The total cost of construction amounts to about $400,000.

(TO BE CONTINUED.)

Armor-Plate Trials*

OBJECT OF THE TRIALS.

The plate, forming part of the turret ordered by the Dutch Government, had on its surface a number of fissures resulting from the process of casting.

According to agreement made the 23rd June, 1883, this trial must prove whether such fissures have any influence on the plate's power of resistance, and must demonstrate the strength of the plate in general.

WITNESSES.

The following named gentlemen were present at these experiments:

From Holland: the Dutch Commission, composed of Lieutenant Colonel Voorduin, Captain Scherer (Artillery), and Captain Snyders (Engineers).

From Germany: From the War Department, Major Strasser, Major Erfling, and Captain Wolff. From the Navy, Captain Bendemann and Lieutenant Kretschmann. From the Inspector General's Department of Artillery, Colonel Von der Hude and Captain Leydhecker. From the First Inspection, Foot Artillery, Lieutenant General Wiebe. From the Artillery Commission for Experiments, Major General Sallbach, Lieutenant Colonel Küper, Lieutenant Colonel Bode, Major Von Engel, Captain Bürklein, Captain Appelmann, Captain von Wietersheim (Navy), Lieutenant Captain von Sperling, and Lieutenant Stiege (Navy). From the Royal Manufactory of Spandau, Major Rausch, Major Schüler, Lieutenant Keppel, and Engineer Pagel. From the R. R. Regiment, Colonel Golz. From the Fortress Commission, Major von Betzold. From Magdeburg, President Wedell-Piesdorf, Colonel von Teichmann, Lieutenant Colonel von Spankeren, Major Goetze, Major Schumann (retired), Major R. Wagner (retired), and Mr. Thiem, (Mayor of Buckau).

From England: Captain Noble.

From Austria: Fieldmarshall Kreutz (President of the first section of the Comitè-Supérieur), Lieutenant Colonel Graf von Geldern-Egmond (Director of Engineers at Krakau), Lieutenant Colonel Beck von Nordenau (Director of Engineers at Pola), Captain von Minutillo (Navy), Captain Victor Tilschkert (Engineer Staff), and Engineer Eduard Brandl (Marines).

From Belgium: Lieutenant General Brialmont and Lieutenant General de Witte (Inspector Generals of Engineers), and Colonel de Cuyper (Inspector General's Department, Artillery).

From China: Ambassador Li-Fong-Pao, Colonel Tscheng-Kitong (Military attaché), and Dr. Charles von Kreyer (Secretary of Legation).

From Denmark: Colonel Koefoed, (Engineers).

From Spain: Colonel Fuentes (Artillery Comité Supérieur).

From Italy: Lieutenant Colonel Rappis and Captain Francesco Preve (Navy).

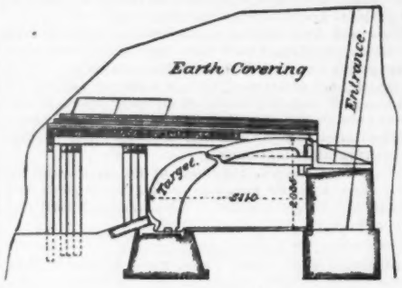
From Japan: Ambassador Siuzo Aoki, Admiral Ito, Major Kasiwa Mura (Miltary attaché), Constructor S. Sasone, and Engineer Wacayama (Marines).

From Portugal: Captain du Bocage (Engineers).

From Roumania: Lieutenant Colonel Robesco (Director, War Department), and Captain Paolo (Engineers).

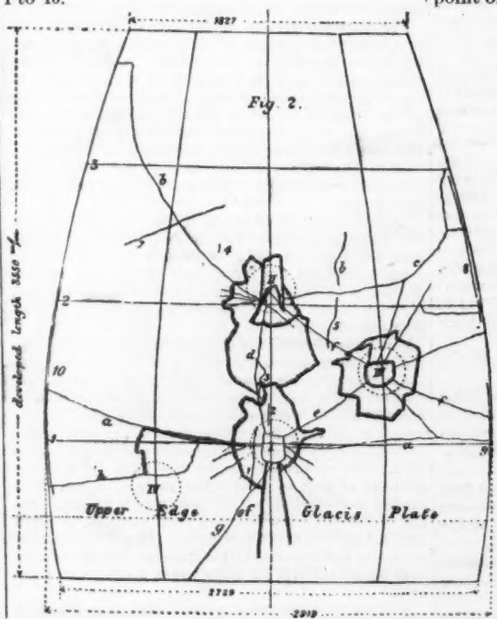
ARRANGEMENT OF THE TARGET.

The trial plate was placed between four others and a cover plate, so that the combination formed half of a complete cupola. The outside plates were braced against three very thick masonry piers by means of three strong connecting plates of ordinary cast-iron.



Above the cover-plate was placed a frame work, which, together with the wooden constructions in front of and on each side of the target, was to receive the splinters of the projectiles. This frame work was made self-supporting, so as not to rest in anyway on the half cupola, and was covered by three layers of rails and a few yards of earth. Inside the turret, reached by a stair-case through a hole dug in the earthen bank, were arranged verticals and measuring rods, for measuring the final displacement of the masonry and of the different plates: one vertical being placed on each side of the middle pier, and the three wooden measuring rods being placed between the foot of the trial-plate and this same pier.

The ten fissures, resulting from the process of casting, are indicated in the annexed sketch, Fig. 2, and are marked by Arabic numbers 1 to 10.



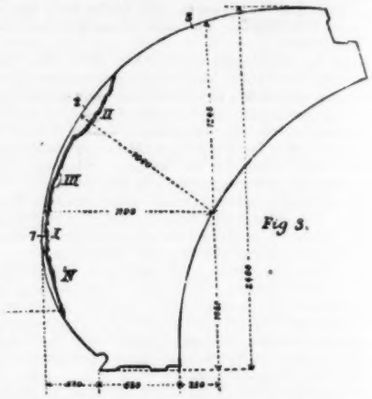
In the present report, the words "right" and "left" are always employed (both outside and inside the target) to mean right and left, respectively, as seen by a person outside of, and in front of, the target.

CONDITIONS OF FIRING.

The cannon made use of was a Krupp cannon of 30.5 centimeters (12.0 inch) caliber, and of 25 calibers length; it was mounted on a Gruson minimum-embrasure carriage (model 1880). The projectiles were Krupp hardened-steel explosive-shells of 3.5 calibers length, and of about 445 kilograms (981 pounds) weight. The charge was 120 kilograms (265 pounds) of Prismatic powder (model 1880). The distance, between the cannon's mouth and the surface of the armor, was 27 meters (88.6 feet). The velocity on impact was 445 meters (1,460 feet). The living force at impact was 4,490 meter-tons (14,490 English foot-tons). The trial armor-plate weighed 47.5 metric (46.6 English) tons.

FIRST SHOT.

Weight of the shell; 445.6 kilograms (982.4 pounds). Depression of the gun; 4 degrees and 6 minutes. Point of impact; 4 centimeters (1.6 inches) to the right of the middle of the plate, 90 centimeters (35.3 inches) abovs its lower edge. Angles of impact; 90 degrees, measured between the last tangent to the



shot's trajectory, and the tangent plane to the surface of the armor plate at the point of impact.

Results:

A horizontal crack (a) was produced, extending to the sides of the plate; and ending on the left hand 125 centimeters (4.1 feet), and on the right-hand side 91 centimeters (3.0 feet), above the lower edge of the plate. The iron scaled off along this crack, on the left of the point of impact, over a surface from 30 to 40 centimeters (12 to 16 inches) in length, and 3 centimeters (1.2 in.) in breadth; it scaled off also around the point of impact to a depth of about 3.5 centimeters (1.4 inches), over a surface of 48 centimeters (18.9 inches) breadth and 52 centimeters (20.5 inches) height. In the middle of the mark, produced by the impact of the projectile, was found the projectile's flattened point, soldered to the plate, forming a disk of about 15 centimeters (5.9 inches) diameter, which swelled outward a little at its center. The projectile's point had not been able to penetrate into the armor-plate; it had simply made an impression of slight depth, and had attached itself to the surface in such fashion that, when afterwards detached, it carried away with itself a small piece of the cast-iron. Five capillary cracks, of slight length, were found radiating from the point of impact.

On the interior of the plate, the crack (a) was visible from a point forty-five centimeters (17.8 inches) distant from the left edge of the plate up to another point 22 centimeters (8.7 inches) from its right edge. A fine crack of 44 centimeters (17.3 inches) had started from the middle of the plate, and ran a little obliquely to the left towards its lower edge. The verticals showed a backward displacement of the cover-plate of 1 millimeter (0.04 inches) on the right, and about 3 millimeter (0.12 inches) on the left. The foot of the trial-plate had also made a small movement toward the interior, as shown by the wooden measuring rods which were partially broken. The joint between the trial-plate and the roof plate was a little tightened, those between the side plates and the roof were slightly widened, and the joints between the trial-plate and the side plates were widened about 2.5 millimeters (0.10 inches) on the inside. Between the connecting plates and the masonry were noticed cracks of 3 millimeters (0.12 inches) on the left, and 1 millimeter (0.04 inches) on the right. The masonry had therefore failed to prevent a displacement of the whole construction, but this displacement

*Made on the 22nd October, 1883, at the Shooting-Grounds of H. Gruson, at Buckau near Magdeburg, Prussia, upon a Chilled-cast-iron Side-plate of an Armored Turret intended to contain two 30.5 Centimeters (12-inch) guns.

Translated from the official Report of M. Gruson, by Wm. H. Bixby, Captain of Engineers, U. S. Army.

was so slight that it was decided to continue the experiment without modification.

SECOND SHOT.

Weight of the projectile; 446.3 kilograms (983.9 pounds). Depression of the cannon; 2 degrees and 12 minutes. Point of impact; on the middle line, 190 centimeters (6.2 feet) above the lower edge. Angle of impact; 51 degrees.

Results:

A crack (b) was produced, commencing at

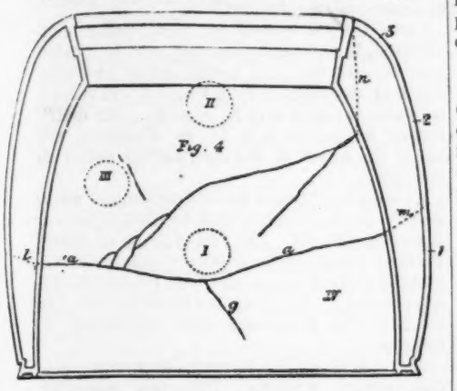


Fig. 4

the point of impact, running in a curved direction toward the upper left-hand corner of the plate ending 50 centimeters (19.7 inches) from its upper edge and 17 centimeters 6.7 inches) from its left edge. Another crack (c) ran from the point of impact, in a curved direction toward the upper right-hand corner of the plate, and after having made a very sharp turn reached the right edge of the plate at 135 centimeters (4.4 feet) from its upper edge. A vertical crack (d) was found connecting the points of impact of shots Nos. 1 and 2. Below the mark of the shot No. 1 and the crack (a) it was impossible to see any crack on the outside, although such a one (g) was found on the inside. Four capillary cracks, 20 centimeters (7.9 inches) long, radiated from the point of impact. The point of the projectile had produced a hollow of 70 millimeters (2.8 inches) maximum depth, of 48 centimeters (18.9 inches) length, and 12 centimeters (4.7 inches) breadth; and had scaled off the outer iron over a surface of 55 centimeters (21.6 inches) maximum breadth.

On the interior of the plate the crack (a) had extended to both lateral edges of the plate, and had a breadth of about 1 millimeter (0.04 inches). The cracks (b) (c) (d) were not visible on the interior. The verticals indicated a new displacement (3 millimeters = 0.12 inches) of the roof-plate toward the interior, a displacement which had been shared by the plate supporting the roof. The foot of the trial plate had remained unmoved. The joint, between the trial plate and the roof, had regained its original breadth, probably in consequence of the displacement of the plate supporting the roof. The joints, between the trial plate and the side plates, were contracted about 0·5 millimeters (0·02 inches.)

It was concluded from the above that the whole construction was still firm and solid. The joints, between the masonry and the side connecting plates, were not any wider than before, so that there was no new reason for allowing the displacement of the supporting plate to interfere with the continuation of the experiments.

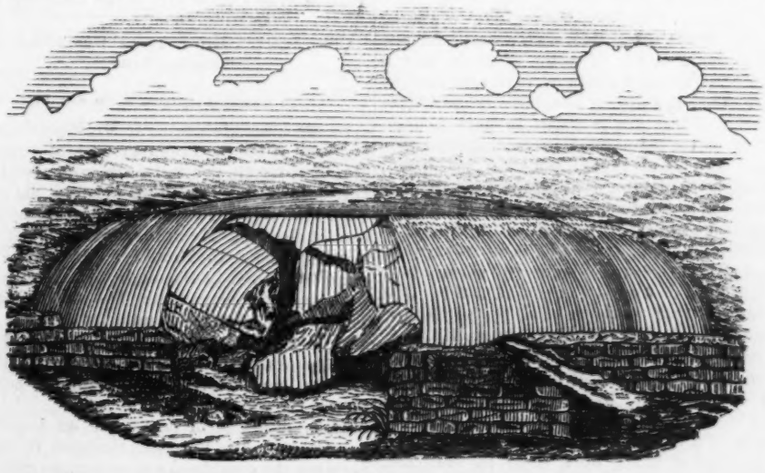
THIRD SHOT.

Weight of the projectile; 443.8 kilograms (978.4 pounds). Depression of the cannon; 3 degrees. Point of impact: 135 centimeters (53 inches) above the lower edge., 71 centimeters (28 inches) from the right edge. Angle of impact; 72 degrees.

Results:

Eight cracks were found radiating from the point of impact; the crack (e) connected the points of impact of shots No. 3 and No 1, and extended beyond them toward the right edge of the plate. Another crack (f) ran parallel to the crack (b) without joining it. The crack (c) was lengthened toward its upper edge; the crack (b) was widened to 7 millimeters (0·28 inches). The point of the projectile had made a hollow of 50 millimeters (2.0 inches) depth, and had scaled off the surface iron in its neighborhood (see sketch).

On the interior of the plate were found two new cracks starting from the same point on the left edge of the plate; one of these cracks was connected to the crack (a) by several short branches; the other disappeared 20 centimeters (7.8 inches) above it. Probably one of them was connected through the plate with the exterior crack (b). Figure 4 shows the back of the plate, as it appeared after the third blow). The vertical indicated a new displacement of the roof-plate 2 millimeters (0·08 inches) toward the interior; the whole right edge of the trial plate had yielded several millimeters; the left-hand side of the plate, and the roof, had scarcely moved. The joint, between the roof-plate and the trial plate, was considerably widened. The joints, between the trial and side-plates, were also widened; the right-hand joint was 3.5 millimeters (0.14 inches) broad at its top, and 9 millimeters (0.35 inches) at its bottom; the left-hand joint was 3.7 millimeters (0.15 inches) broad at its top, and 4.3 millimeters (0.17 inches) at its bottom. The crack, between the masonry and the left-hand side-connecting plate, was 6 millimeters (0.24 inches) broad; on the right hand there was no perceptible change.



It was evident that the resistance of the construction was very much weakened, because all of the plates had yielded and the joints were no longer tight; nevertheless it was supposed that the casemate would resist a fourth blow.

FOURTH SHOT.

Weight of the projectile; 444.6 kilograms (980.2 pounds). Depression of the cannon: 4 degrees and 30 minutes. Point of impact: 75 centimeters (29·5 inches) from the left-hand edge, and 65 centimeters (25.6 inches) above the lower edge of the plate. Angle of impact: about 75 degrees.

Results:

By the fourth shot the plate was breached; that is to say, the fragment between the crack (a) and the two new cracks (g) and (h), was knocked completely out of the plate and thrown into the interior as far as the middle pier. Other portions of the plate, around th hole then fell inward, partially closing this hole, but at the same time extending the breach to the rest of the plate. In this way the plate was divided by the cracks (a) (b) (c) (d) (f) (g) into six pieces. The roof rested in place; but between the side-connecting-plates and the piers, the joints had opened about 15 millimeters (0.59 inches).

It was evident that the whole construction had moved laterally under the shock of the projectile. This conclusion was confirmed by the removal of the earthern embankment. It was then seen that between the roof and the two left-hand side-plates there was an open gap, 30 millimeters (1.18 inches) broad, caused by the backward movement of both side-plates and foundation-plates.

SUMMARY.

The trial-plate had successfully resisted three blows, whose total living force was 13,470 meter tons (43,470 English foot-tons), or 283.6 meter-tons per ton of its weight (931 English foot-tons per English ton); and during these blows it had continuously afforded a solid and effective shelter to the interior of the turret. After these three blows: the plate showed a number of cracks, extending partially across the whole breadth and the whole thickness of the plate, and dividing it into several large portions which had not left their original positions. The surface iron had been scaled off around the points of impact, and shallow cavities had been produced at their centres; but the points of the projectiles had nowhere been able to penetrate more than 7 centimeters (2.8 inches) into the plate.

The provisional mounting of the trial plate had not been sufficient to prevent it from considerable displacement. The unexpected result of the fourth shot was due in part to these displacements. Before the last shot the plate was divided into two parts by the crack (a); the crack (g) showed on the rear; thus the small lower left-hand portion of the plate was nearly detached. If the other plates, and the masonry construction, had not been driven back, this portion would have perhaps resisted another blow. For want of sufficient stability to the entire construction, it was possible for all the living force of the shot to be applied to the displacement of this relatively small portion of the plate, and thus to breach the plate.

The surface fissures, produced during the casting of the plate, had nowhere contributed to the destruction of the plate. The sketch shows clearly that the tracks, produced by the shock of the projectiles, had a direction perfectly independent of these fissures; and that the latter had not even been elongated under the influence of the enormous blows to which the trial-plate had been subjected.

As has always been the case in every preceeding trial, the steel projectiles, upon striking the chilled iron, were in each case reduced to numerous splinters, whose size varied between that of a pea and a man's fist. These splinters were found in the beams and roof around the target.

ENGINEERING NEWS: Three months for One Dollar.

The Water Supply of Baltimore.

The last report of the Chief Engineer of Baltimore contains some interesting figures relating to the construction, capacity and cost of Baltimore's new water supply, which we reproduce.

In addition to the Gunpowder supply, Baltimore is also supplied with water from the Jones' Falls' supply, which embraces Lake Roland, 225 ft. above tide, one and a half miles long, with an average width of one-eighth of a mile and a water surface of 116 acres; a conduit four miles long; Hampden Reservoir, 217 ft. above tide and eight acres water surface; Druid Lake, in Druid Hill Park, 217 ft. above tide, depth 20 to 65 ft., with 53 acres of water surface, surrounded by a drive of one and a half miles; High Service Reservoir, 350 ft. above tide, with a water surface of four acres; Mount Royal Reservoir, 150 ft. above tide, with a water surface of five acres.

Loch Raven was begun December 22, 1875, and completed November, 1880. The lake is four and three-fourths miles in length; the elevation of water surface at high-water mark is 170 ft. above tide. The width of the lake is from 100 ft. to 800 ft.; it covers an area of water surface of 252 acres, and is from 4 to 20 ft. in depth. The capacity of the lake is 510,000,000 of gallons, and is surrounded by a roadway from 30 ft. to 50 ft. in width; elevation of surface of roadway 180 feet above tide. Nine bridges span the streams emptying into the lake, and all, with one exception, are of marble.

Concrete and masonry, 91.85 perches laid at $3 per perch; rubble masonry, 3,980.89, at $4 per perch; rough-hammered masonry, 436.47 perches, at $4.75 per perch. Total number of cu. yds. of earth excavated, 688,207, at 16 cents per cu. yd.; loose rock, 99,777.41 cu. yds., at 38 cents; solid rock, 77,973 cu. yds., at 60 cents.

The Loch Raven dam was commenced December 3, 1875, and completed October 6, 1881. It is built of rubble and cut stone, and the masonry cost $255,950.57. The width of the overfall is 300 ft. number of stones in face of the dam 2,530, the dimensions of each being about 25 cu. ft. The height of the dam, from foundation to crest line, is 29 ft., the thickness of the foundation is 62 ft., depth of the foundation below original surface is 13 ft. The north wing wall of the dam is 205 ft. in length, length of north retaining wall 197.3 ft., south retaining wall 200 ft.

The flow of water at the dam is controlled by a gate-house, the chambers of which are built of white marble. The gate-house superstructure is a parallelogram in form.

The width of the gate-house superstructure is 45½ ft., length 70 ft., thickness of walls 2 ft. 6 in., cost of constructing walls of superstructure $7,890. Within the gate-house are located 17 gates, with opening 3 by four ft., costing $398 per gate.

Earth excavations, 117,175 cubic yards, at 18 cents; loose rock, 37,192 cubic yards, at 40 cents; solid rock, 19,816 cubic yards, at 75 cents; concrete masonry, 463.44 perches, average price $2.25 per perch; rubble masonry, 13,219.20 perches, at $5.57; rock ashlar masonry, 4,549.62 perches, average price $16.53; dressed ashlar, 1,706.39 perches, at $24.65; rock hammered masonry, 437.35 perches, at $6.

The main tunnel connecting Loch Raven with Lake Montebello was commenced December 15, 1875, and completed November, 1880. Its length from the portal in Loch Raven gate-house to portal in Montebello gate-house is 36,443 ft. or 517 ft. less than seven miles; and it is a circular bore, with an internal diameter of twelve feet, and a fall of one foot to the mile. For 24,752 ft. or nearly four and a half miles, its course is through hard rock, which required no arching, and where the drifts had to be pushed by hand-drilling and dynamite blasting. The remaining 11,691 ft. or about 100 ft. more than two miles, is arched with bricks. The cost of graduation was $1,382,598.93; arching, cleaning up tunnel, filling shafts, $397,011.32. The total cost of the main tunnel was $1,779,610.24. The capacity of discharge of the tunnel per twenty-four hours is 170,000,000 gallons. The depth of the bottom grade below the surface is from 36 ft. to 354 ft. In the construction of the tunnel 15 shafts were sunk, and they were located at an average distance of 2,337 ft. apart on centre line of tunnel and parallel to its axis. The longest drive between shafts was 3,075 ft. and the minimum 1,890 ft. The maximum depth of shafting sunk in hard rock per month was 37.5 ft; minumum depth in hard rock per month, 15.5 ft.; maximum depth in soft rock per month, 44 ft.; minimum, 38 ft. Number of lineal ft. of shafting, 2,354 ft.; dimension of shafts in rock excavation, from 17 ft. by 8 ft. to 20 ft. by 8 ft. Greatest depth of shaft 294.91 ft. The total number of cu. yds. of shaft-in main tunnel was 19,256; average price paid per cu. yd. of shafting, $10.03.

Drifting.—In heading the maximum distance driven in hard rock was 114 ft. per month; minimum, 10 ft. Maximum distance driven in soft rock per month 170 ft; minimum, 12 ft. In bottom—Maximum distance driven in soft rock per month, 300 ft. minimum, 10 ft. Maximum distance driven in hard rock per month, 112 ft. minimum, 12 ft. Maximum distance driven in hard rock in full area of tunnel per month, 80 ft., minimum, 10 ft. Total number of cu. yds. of drifting on main tunnel, 176,579; average price paid per cu. yd. for drifting, $6.62. Cost of brick work per perch, done by day's labor, $15; number of perches of brick work per lineal foot in arch and invert, exclusive of arching over the shafts, 2.07; cost of brick work per lineal foot in arch and invert done by day's labor, $31.05.

Lake Montebello was commenced December 1, 1875, and completed December, 1880. It is the receiving reservoir of the Gunpowder water supply. The lake is irregular in shape, is 163 ft. above mean tide, with a water surface of 59 acres, a depth of water of 30 ft. and a drive of an average width of 70 ft. and 7,265 ft. long. The capacity of the lake is 496,378,144 gallons. There are 29 gates in gate houses, size of each, three by four feet, costing $398 each. The drain tunnel is 3,432 ft. in length, and required about a year and a half to construct. It is circular in form, with an internal diameter of nine feet; 2,873 ft. of the tunnel is arched with brick, and 512 ft. is in solid rock. The depth of the tunnel below the surface is 28 to 62 ft.; fall of tunnel per 100 ft. .085 ft.; fall of tunnel from west to east portal 29.6 ft.; number of shafts, including air shaft, 3; average depth of shafts, below the surface, 43 ft.; perches per lineal foot of brick work in arch and invert, done by contract, 1.26; cost of brick work per lineal foot by contract and exclusive of arching over shafts, $13.23; number of perches of brick work done by contract, 3,721, at $10.50 per perch. Total cost of drain tunnel, $97,102,96.

The supply of water for the city after it leaves the gate-house at Lake Montebello is conveyed in a conduit, built partly in tunnel and partly open cut, a distance of 5,410 ft. to the gate-house at Lake Clifton. The conduit was commenced August, 1876, and completed August, 1878. It is circular and arched with brick, and has an internal diameter of 12 ft. Only one shaft was sunk, at a depth of 33.5 ft. below the surface. The depth of the conduit below the surface is from 29 ft. to 110 ft. The cost of drifting, including packing over arch, by contract was $4.50 per cu. yd.; cost of brick work per perch, done by day's work in open cut of tunnel, $9.58; in tunnel, $12.75; cost of brick work per lineal foot in open cut, $25.48; in tunnel, $37.74; perches of, in arch and invert, 2.96; perches in open cut, 2.66.

There is also an elliptical conduit, constructed during October, November and December of 1877, which is 198.5 ft. in length, with a long axis of 18 ft., and a short axis of 12 ft. Approach to the conduit 51.5 ft. in length. Discharge conduit, 1,083 ft. in length, with an internal diameter of 12 ft. constructed partly in excavation and partly in embankment. Earth excavation, 719,318 cu. yds., at 21 cents per cu. yd.; loose rock, 156,405 cu. yds., at 24 cents; puddling, 65.599 cu. yds, at 15 cents; concrete masonry, 98 perches, at $2.75; rubble, 16.95 perches at $5. Gate-house superstructure. Hexagon in form. Length of each side, 41 ft.; thickness of walls, 2½ ft. cost of building walls of superstructure, $14, 923.75.

Lake Clifton which is now being constructed, is a storage reservoir, and is located just beyond the city limits, about one mile south of Montebello, from which it will receive its water through a 12 ft. conduit. Six distributing mains, each 40 in. in diameter, will bring the water to the distributing mains in the city.

Ground was broken for the permanent water supply on December 3, 1875, by Civil Engineer Robert K. Martin. The two systems of Jones' Falls and Gunpowder River are capable of furnishing daily a supply of about 165,000,000 gallons of water. To this must be added the sum total of the reservoirs and aqueducts, as follows:

Jones' Falls.—Lake Roland, 400,000,000; conduit (daily), 3,500,000; Hampden reservoir, 46,000,000; Druid Lake, 429,000,000; High Service reservoir, 27,000,000; Mount Royal, 30,000,000; total, 935,500,000.

Gunpowder.—Loch Raven, 510,000,000; conduit (daily), 30,000,000; Montebello, 500,000,000; Clifton, 265,000,000; total, 1,305,000,000. Grand total, 2,240,500,000 gallons.

The cost of the Gunpowder supply, exclusive of Lake Clifton, for which $500,000 in bonds have been issued, was about $4,000,000, and the total cost of the two systems about $10,000,000. The capacity of Baltimore's supply exceeds by far that of any other city in the country.

Comparative Economy of Combined and Separate Sewers.*

BY ROBERT E. McMATH, M. AM. SOC. C. E.

In Mr. Chanute's reply to Mr. Moore's paper, the cost of the St. Louis system of sewers is stated at $30,146 per mile, and contrasted with the cost of the Memphis system, stated at $6,875 per mile. In the same paragraph the cost of cleaning Memphis sewers $70 per mile, is contrasted with Brooklyn $133 and Providence $282. St. Louis ought to have appeared in this second comparison. The cost of cleaning has averaged $23.71 per mile for 7 years, 1878-1884, ordinary repairs $20.39, together $44.10. Chicago sewers in 1884 cost $14.73 for ordinary repairs, and $89.02 for cleaning, together, $103.80 per mile.

Since questions of cost have an important bearing upon the practical decision or choice between the combined and separate systems in any specific case, it is essential that such comparisons should be fair and on equal terms. If St. Louis is to be used as an example of the cost of a combined system, then an estimated cost of sewering St. Louis by the separate system should be the other side of the comparison. Also, since the estimate for the separate system would be based on present prices, methods of work and material, the contrasted figures of actual cost should, in fairness, be cleared of the effect of war inflation prices, and of obsolete ideas, methods and materials. In other words present practice under both systems should be compared, and not the combination of accidents represented by the aggregate cost given in reports.

Clear the cost of St. Louis sewers of items irrelative to the discussion, and the combined system will not suffer if St. Louis be taken as a representative.

The total cost of sewers, including mainte-

*Read at Meeting of St. Louis Engineer's Club May 7th 1884.

nance and miscellaneous expenses for over 30 years, is stated in the report for the year ending April, 1883, at $6,571,733.39. Mileage 218.31; from these figures Mr. Chanute would have got $30,103 per mile. But the same report says the aggregate for maintenance and expenses was $784,868.22, making this reduction, the construction cost is found to be $26,508 per mile.

St. Louis sewers should be classed as trunk, main branch and lateral. Of the four trunk sewers, Ferry reaches about 3 per cent. of its ultimate drainage; Rocky Branch and Mill creek each 28 per cent., and Southern sewer 1.4 per cent: consequently the accounts show a large part of the ultimate cost of a sewer system, but only a small fraction of the ultimate mileage, hence an excessive present average cost per mile, which misrepresents the real expense of the contemplated system. The largest of these trunk sewers has cost nearly $75 per running foot, the smallest nearly $18. Mean of the four $241,296.00 per mile. Obviously it would not be fair to compare St. Louis with a smaller city, or one whose topography did not necessitate such large trunks, as contrasted cases of the combined system, let alone a comparison of systems.

The trunk and main sewers, as now built and planned, would be necessary for St. Louis, whether the combined or separate system were adopted for detail drainage, because the length and discharge of the water courses is too great to be treated in any other way in a large city. The St. Louis branch and lateral sewers by themselves constitute the system which should be compared in discussing the subject. These embrace (April, 1884) 174.92 miles, and have cost $2,932,588.34, or $16,765 per mile. But this cost includes much work done when it was thought that all sewers should be large enough for a man to enter, hence brick sewers were built where pipes would now be used, moreover a great deal was done at inflation or war prices in 1862-1873. From 1873 to 1883 the mean cost was $12,808 per mile. The substitution of pipe sewers to the full extent possible under the combined system dates from 1877, therefore the work done from 1877 to 1884 is what should be taken as representing present practice. The average cost per mile during these years has been $10,271, and some of these were laid in rock excavation; the cost includes inlets, manholes and junctions. Taking St. Louis prices, I estimate the average cost of separate sewers for house drainage alone with junctions and manholes at $6,080 per mile, or $59\frac{7}{10}$ per cent. of the present cost of the combined system. For the same territory an equal mileage would be required, hence cost per unit of area will be in the same proportion as per unit of length. The mean cost per square, of 100 square feet, since 1877, has been $1.28\frac{1}{4}$. The proportion $59\frac{7}{10}$ per cent. would give for a separate system $0.76 per square. For an ordinary sized city lot, 25 by 130 feet, the sewer tax at above rates would be $41.73 and $24.70, respectively. The real question at issue is which system is best worth its cost to the lot owner. The money difference, $16.97, is an insignificant fraction of the cost of a residence or business house.

Connecting the house with the sewer will cost practically the same under either system; but the separate will leave the owner with storm-water from roof and lot surface undisposed of; by the comparison above he has a balance of $17.00 as compensation for the inconvenience, or as a fund with which to lay storm-water drains. Ordinarily the drains required to carry the water to the street gutter will consume the balance. Hence for city conditions the claim of economy made for the separate system is unwarranted. If the average lot front was 50 feet, there would be a small advantage in favor of the separate system, this advantage would increase with the dimensions of lot, that is, under the conditions, of a large business town and dense population, the combined system is the cheaper as well as better adapted to the requirements. The separate system, on the other hand, is well adapted to villages and city suburbs, where economy in mileage cost is a necessity, and where surface waters are uncontaminated by traffic and diminished in quantity by the absorbent surface of lawns and cultivated plots.

The Sewerage of Kansas City.

KANSAS CITY, MO., May 16, 1884.

EDITOR ENGINEERING NEWS: The discussion between Messrs Moore and Chanute, published in your columns, is of more than usual interest, both parties being prominent Engineers, and having no other aim than to arrive at the best result attained.

Mr. Chanute has the advantage of an intimate knowledge of the locality, and has been stimulated in his studies by heavy tax bills. Others besides the writer will take issue with Mr. Moore concerning the nuisance of storm-water, and recall many devices for passing such water by street intersections besides the tiles, mentioned by Mr. Conover in your issue of 3d inst. Box drains, of which the top forms a cross-walk are common and made in many ways, among which, a recent invention is worthy of notice; in this the drain is covered with a wooden grating of two or three inch stuff set edgewise, half an inch apart, in an iron frame-work; this insures a dry cross-walk so long as the drain is unobstructed, and when obstructed offers good facilities for cleaning.

The writer spent a year in Memphis before the sewerage system now in use there was introduced; his business being upon the street in all weathers, gave a good means of knowing just about how much of a nuisance storm-water was. Although storms are much more frequent there than here, he did not see much nuisance of this description, and the streets, so far as their surface was concerned, were much cleaner than the best sewered part of Kansas city to-day. A recent visit to Memphis in a severe and protracted storm, during which he had to go over considerable of the business part of the town on foot, showed the same state of things existing now.

The fact is, the citizens of Memphis clean their streets instead of waiting two or three months for a storm to wash a portion of the debris into catch-basins and make the street impassable with the rest of it.

Mr. Moore, however, allows that storm-water may be permitted to run 1000 ft. before it becomes a very great nuisance; this is a great concession. If storm-water can run 500 ft. on level ground before it is too much in the way, it can run 1500 on some of our steep grades, and experience shows this to be true where breadth is not added to length. We may then assume that storm-water sewers need not reach nearer the margin of the water-shed than from two to five squares; if this had been acted upon here, it would have reduced the amount of large sewers fully one half.

Some persons seem to think that the separate system is best adopted to areas of small grade. As storm-water lies longest in such places and is therefore most in the way there, it would seem that the storm-water sewers were needed there, not only larger but closer together. In the low grades the use of covered cross-drains is also more difficult on account of the street intersections being too level to obtain a good current through them. It is a very good point for the opponents of the separate system if they can get their large sewers into high ground, for it is evident that if they do, they must be continued through the low ground to their outlets, and there is no place left for the separate sewers.

With regard to the health of Memphis, both citizens and public officers claim that great injustice is done, not only to the system of sewerage adopted, but to the city, by the fact that its recent growths has been very rapid, and this very much mitigates the percentages shown in the mortuary tables; they also point to the facts that a large part of the low lying districts of the city are not yet sewered, and that the water supply is in corresponding need of improvement. Whatever may be the real facts as to these data, it is plain that confidence in the future health of the city has filled its empty houses and invigorated its industries, and more general satisfaction with the system of sewerage adopted cannot probably be found in any town in America.

Regarding the citation of Croydon as offered to the evidence in favor of the separate system, the writer is unable to find that its lessons apply to the present usage. It indeed shows that any sewers need more cleansing than can be depended on from storms, at least in this section, and as to "laying on" sewer gas his experience shows that it is the one thing most securely and constantly guarded against.

The question of depth is not pertinent as applied to the Memphis sewers; a majority of buildings there have ventilating spaces underneath, instead of basements—the sewers there were deep enough for their requirements and the manholes, left out from motives of temporary economy, have since been put in when and where they were found to be needed without much if any added expense.

In another town the writer has placed sewers from 9 to 27 ft. deep, and with all the manholes he thought necessary.

It would be unfair to criticise the sewerage of this city as the work of any individual; it has been built piecemeal by different engineers, and very much of it in the immediate interests of local property owners; the consequence, as the present engineer states in one of his reports, is that many sewer districts do not conform to the best use of the topography, and this has no doubt been the cause of injustice to some citizens.

Some data will assist in an understanding of this discussion. In lower town* the ground being almost level and intersected in all directions by railroads, the sizes of city lots being variable and the limits of use of the present sewers indefinite, make more than an approximation difficult; similar areas of broken ground and the non-conformity of the sewer districts to the water-shed, makes a similar case on the hill. Approximately an area in lower town contains about 200 acres besides a considerable area of outlying railroad ground drained into it. This has two sewers, one 5 ft. in diameter the other 4×5 ft., both braches aggregating some 11,000 ft., and accessible from about 300 city lots, leaving some 700 unprovided for, and will require nearly as much more, making perhaps 20,000 ft. in this area, of which about 5,000 ft. are needed for storm-water.

The Broadway sewer has a water-shed of some 140 acres, part of which may have a separate line to the river. At present the sewer is 3 ft. with a heavy grade; takes in as branches two 30 inch sewer, two 18 inch sewer and about half a dozen catch-basins before its own size is reduced to 30 inches. In the upper part of this district a 36" sewer, two 18" sewers and two 15" sewers lie in parallel streets and alleys within a breadth of 650 ft. The present sewerage in this area is about 18,000 ft., accessible by about 400 lots and leaving some 200 to be provided for, which will increase the sewerage to perhaps 23,000 ft. Storm-water sewerage required in this area about $\frac{1}{4}$ of this amount. These areas are perhaps as different in their characteristics as any in the city. They seem to indicate that from one fourth to one fifth of the whole amount of sewerage needed is required for storm-water, and that the remaining $\frac{3}{4}$ or $\frac{4}{5}$ might be properly constructed in the less expensive manner of the separate system, using the larger low lying sewers as an outlet. But no person without patient study of details can determine how each case can be best provided for.

It would seem that the best results could be attained by an unprejudiced and disinterested combination of both systems.

It is natural to any one having new plans to urge, to place them in the foreground, and as natural for those favoring old systems to ignore as much as possible the benefits to be derived from the new. Both these under discussion have valuable features, and those who, like the writer, have no personal interest in the matter will not be deterred by the first from holding on to what they consider good, nor afraid, like the second, that they will injure themselves or their employés if they see reason to take hold of something new because it may happen to be patented.

G. W. PEARSONS.

*We infer by this expression is meant the low land at the foot of the bluff, characteristic of many towns on the western rivers. The text is obscure as to the special city referred to in the above description; the writer is engineer for the new sewerage of Leavenworth, Kan.—ED. ENG. NEWS.

Engineering News

AND

AMERICAN CONTRACT JOURNAL.

Tribune Building, - - - New York City.

THE ENGINEERING NEWS PUBLISHING CO. PROPRIETOR.

PUBLISHED EVERY SATURDAY.

CONDUCTED BY

GEO. H. FROST, - - - Assoc. Am. Soc. C. E.
D. McN. STAUFFER, M.Am.Soc.C.E.: M.Inst.C.E.

TERMS OF SUBSCRIPTION:

$4.00.....PER YEAR TO U. S. AND CANADA.
$5.00..... " " " FOREIGN COUNTRIES.

TABLE OF CONTENTS.

	PAGE
The Monongahela Bridge (*Illustrated*)	251
Armor Plate Trials (*Illustrated*)	254
The Water Supply of Baltimore	256
Comparative Economy of Combined and Separate Sewers	256
The Sewerage of Kansas City	257
The Panama Canal	258
The Institution of Civil Engineers	258
The Philadelphia Water Department	258
American Institution of Electrical Engineers	259
Additional List of Papers to be Presented at the Buffalo Convention	259
Personal	259
Obituary	259
Mechanical Engineers	259
American Society of Civil Engineers	260
Correspondence	260
Literature	260
History and Statistics of Amer. Water Works	262
Water	262
News of Week	263
Markets	264

Make all drafts, cheques and money orders payable to **Engineering News Publishing Co.**

WE wish to call attention of intending visitors to the Buffalo Convention of the American Society of Civil Engineers, to the importance of handing in as early as possible their names and addresses, and those of accompanying ladies, so that they may be prepared for early and correct publication. The duties of Secretary Bogart and his assistants during the few days of the Convention are very numerous and exacting, and much unnecessary trouble and time may be saved by a little thoughtfulness and prompt action of the members; it is very important to have an accurate register of the attendance at the Convention, but the labor of securing it is hardly appreciated by the visitors themselves. Please to hand in names as early as possible.

THE Secretaries of War and the Navy have appointed Gen. JOHN NEWTON, Chief of Engineers; Col. Q. A. GILLMORE, Corps of Engineers, and Lieut.-Commander B. H. MCCALLA, members, and Lieut. T. H. BLISS, First Artillery, Recorder, of a board created by a resolution of the House of Representatives to consider the expediency of the construction of a line of interior waterways for the protection of the seaboard of the Atlantic and Gulf States.

THE Councils of Wyandotte, Kansas, have generously fixed the salary of their "City Engineer" at $3.50 per day, "for time actually employed."

As this is about the pay of a good mechanic, the guardians of Wyandotte have either the usual bucolic appreciation of the value of the services of an engineer, or have an unusually bad lot to select from.

Our chief objection is to the use of the term "engineer," for no man worthy of that title can be hired on the terms and salary stated. Wyandotte probably imagines that a transitman or leveller is equal to the engineering demands of the present; an engineer will be called in later, to correct the blunders of construction and rebuild her public-works, if she has any.

ROBERT H. THURSTON, President of the Mechanical Section of the American Association for the Advancement of Science, has issued a circular letter, calling the attention of members, actual and prospective, to the coming meeting in Philadelphia, Sept. 3, 10, 1884.

It is expected that this meeting will be one of singular interest, worthy alike of the occasion and of the opportunity. The members of the British Association, which meets later in Montreal, are expected to be in Philadelphia on Sept. 3; and the Electrical Exhibition now preparing under the auspices of the Franklin Institute will add an additional attraction.

Members are requested to forward titles and abstracts of papers to be read before the Association, and give notice of space required for models, etc. Only papers of a scientific character will be considered; all advertising matter will be rejected.

AT the meeting of The American Society of Civil Engineers on Wednesday, May 21st, Secretary Bogart announced that over 300 members and their friends, including about 75 ladies, had expressed their purpose of going to the Buffalo Convention by the special train of June 9th, over the N. Y. West Shore and Buffalo R. R. All indications point towards a numerously attended and most successful meeting. There will be a number of the older members of the profession, who have not yet attended any of the Conventions, present at Buffalo, induced to go by the nearness of, and the comparative comfort of getting to, the place of meeting.

WE have been asked if the meetings of the American Society of Civil Engineers at the annual Conventions are open to engineers and surveyors, not members. In reply we assure our correspondents that these meetings for the reading and discussion of papers are free to all who wish to come, and it is especially desirable that engineers avail themselves of the opportunity of learning some of the advantages of association with their professional brethren.

Excursions and entertainments are matters of local courtesy and control, and to participate in them it is necessary to obtain invitations from the local committees. The Society itself is a guest of the always generous citizens of the city visited.

The Institution of Civil Engineers.

London *Engineering* editorially comments upon defects in the organization and administration of the Institution of Civil Engineers. The conditions of the profession have so much changed since the date of drawing up the original by-laws that some revision is needed, especially in the means provided for the election of the President and Council.

According to the terms of the Royal Charter, the voting power rests wholly with the members present at the general meeting called for that purpose. As at present 68 per cent. of the total membership are non-resident, the actual majority is not represented in the selection of officers; practically, the President of the most prominent Society of Engineers, whose members to the number of 4,000, are engaged in great works all over the world, is selected by a majority of the two or three hundred who happen to be in London, and are disengaged on some one particular day in the year.

While the real prosperity and usefulness of the Society depends very much upon these non-resident members, their connection is confined solely to the annual payment of a subscription and the receipt of the admirable and bulky Minutes of Proceedings, otherwise they are treated as having no existence.

Under the charter, this evil can only be corrected by a supplementary charter, and this can be granted only when practically the whole of the members are in favor of the proposed change. Herein lies the difficulty, for there is no recognized means of learning the will of the members except by personal voting, and under the present conditions this is an impossibility.

In this dilemma Mr. Alexander R. Binnie, of Bradford, is attempting to gather such an expression of opinion as will justify the council in making the departure from the regular and customary courses of procedure which the case requires. To this end he has issued a letter to every member pointing out the reasons for the proposed change, and in sending out his letters has posted them at such intervals of time as will bring the answers to London about the same date. This last is for the purpose of testing the feasibility of a letter ballot among a constituency so widely scattered.

The Philadelphia Water Department.

The last annual report of the Philadelphia Water Department, reviewed in this issue, is a noteworthy document. It is thorough in its treatment, vigorous and fearless in its language. The chief engineer has introduced an element of discipline, subordination and individual responsibility into his department that is as wholesome and proper as it is rare in the management of city affairs. For this, he and the community he serves, are no doubt much indebted to his own previous military training.

Advocating the very proper but unusual doctrine that private business methods can be followed in conducting municipal affairs, he strikes at the root of the prevalent evil by eliminating politics from the selection of his agents, and permitting personal merit alone to influence his appointments. The carrying into practice of this policy must have required almost herculean effort upon the part of the chief of the department, but by a combination of personal force of character and a change of heart in the governing authorities, he seems to have succeeded "fairly well," as he himself expresses it.

This question of politics lies at the bottom of all the corruption prevalent in our great cities, and as long as a place is the reward for most questionable political service, which can only be performed by the evil class in a community, this corruption, inefficiency and waste must continue. A bad man neither wishes to, nor can perform a good man's work, and when some other than the head of a department controls the appointment and discharge of its employés, the department itself must necessarily suffer.

Chief Engineer Ludlow in his report, comments very severely upon the condition in which he found the department when placed in charge. He hardly takes into consideration, we fear, the elements which influenced and controlled the administration of his immediate predecessor, nor the very different conditions existing when he himself came into office. The department for some years previous to 1883 had been virtually in a state of siege, with much needed supplies cut off, recommendations ignored, and a bitter war going on between the then chief and the city councils. We need not now refer to the causes for this deplorable state of affairs, but from some intimate knowledge of these causes, we can say that the old chief deserved much credit for, in the face of all these difficulties, conducting the department as well as he did.

The present report shows that while the surplus of revenue over receipts, for 28 years, was something over $8,000,000, the surplus for the last ten years of that time, which virtually covered the reign of the past chief, was nearly $5,500,000, thus showing that the department was honestly administered, and that the want of revenue was not the reason for the denial of all appropriations for extension, so badly needed and often asked for. He had to meet a constantly increasing demand for water with

whatever amount was begrudgingly bestowed upon him, and that the plant was run down and extensive repairs and additions sadly needed is proven by the work of the present administration. But it is only fair to remark that almost without exception the additions of the past year and the many suggestions for future improvement are repetitions of old stories that in the past fell upon unwilling ears.

We would not for a moment deny the renewed vigor and healthy and radical improvement evident in the department as now existing; for this Chief Engineer Ludlow cannot be too much praised, and he certainly has worked miracles in the new order of things which he has brought about; but in a spirit of fairness, we do think that the very much altered relations between the chief and the city authorities should be allowed a proper place as a factor in bringing about this revolution. The present chief must, and does admit that without concerted action upon the part of the department and those who control the purse-strings, any system of improvement or even economical management would be slow and uncertain, if not impossible. By the very manner of his appointment Chief Ludlow is independent in a great measure, of the political powers, and even these are now much purer and more inclined toward reform than for years past. Practically untrammeled by outside influence, and with a personal force of character that will brook no interference, the present chief presents to the world that anomoly, a public official who can administer his office without fear or favor.

Even in the appointment of employés, the method pursued by the present chief was simply impossible to his predecessor; with an army of political employés against him, self-preservation compelled him to fight the devil with fire, and use men skilled in politics rather than those who would have better served the needs of his department. This necessity does not at present exist; the evil powers of past years have ceased to reign, and to this fact the present administration is mainly indebted for the means of putting into practice a policy which would not have been permitted a few years ago, and would now, in many other cities, be looked upon as a most unwarranted assumption of power, and a downright outrage upon the rights of the professional politician and his constituents.

We congratulate Philadelphia upon its purer political atmosphere, and upon the possession of a model official at the head of its Water Department.

American Institute of Electrical Engineers.

At the call of a number of prominent electricians a meeting was held on the 13th of May, in the rooms of American Society of Civil Engineers, New York, and the organization of the above named society was effected.

The first of its kind in this country, it bids fair to have a prosperous career, and will undoubtedly tend to promote the interests of all those engaged in electrical pursuits. That the only society is a representative one, will be seen by the list of officers elected which is as follows:

President: Dr. Norvin Green.

Vice-president: A. Graham Bell, Charles T. Cross, Thomas A. Edison, George A. Hamilton, Charles H. Haskins, Frank L. Pope.

Managers: Charles F. Brush, William H. Eckert, Stephen D. Field, Elisha Gray, Edwin J. Houston, C. L. Billings, Frank W. Jones, George B. Prescott, W. W. Smith, W. P. Trowbridge, Theodore N. Vail, Edward Weston.

Treasurer: Rowland R. Hazard; Secretary: Nathaniel S. Keith.

THE city council of Council Bluffs, Iowa, has just passed a good-sized batch of ordinances for paving, curbing, sewerage, etc.

Additional List of Papers to be Presented at the Buffalo Convention.

TITLE OF PAPER.	AUTHOR.
Water Rates	J. J. R. CROES.
Test of a Water Wheel	JAMES B. FRANCIS.
Submerged Weirs	JAMES B. FRANCIS.
Substructure as an Engineering Problem	J. ALBERT MONROE.
The American Line from Vera Cruz to City of Mexico	A. M. WELLINGTON.
Concentration of Flood Waters and Mississippi Levees tested by Facts	R. E. MCMATH.
The Ravages of the Teredo	C.ENG. P. C. ASSERSON, U.S.N
The Heavy Gun Question	C'PT. O. E. MICHAELIS, U.S.A
Management of Forces engaged in Track Repairs	BENJ. REECE.
Co-operation between the General and State Governments in making Topographical Surveys	H. F. WALLING.

PERSONAL.

JOHN P. HALLER, of Lima, O., has been elected City Civil Engineer for the third term.

JOHNSTON LIVINGSTON has been elected a Director of the North Pacific Railroad in place of HENRY E. JOHNSTON, of Baltimore, deceased.

LIEUT. W. H. H. SOUTHERLAND, of the branch United States Hydrographic Office, has just passed a successful examination at Washington.

JOHN GRAHAM was re-elected City Civil Engineer, of Columbus, O., with A. G. PUGH and WILL GRAHAM as assistants.

W. B. HAYDEN was re-elected President of the Water-Works trustees.

C. N. DANENHOWER has resigned his position as Assisstant Engineer U. S. Engineer Corps under CAPT. R. L. HOXIE, Washington, D. C. to accept the office of Chief Engineer of the Board of Public Works of Cincinnati, O., at which city he must be addressed hereafter.

THE Mexican Central party were received by President GONZALES and the Secretary of Public Works at noon on May 14. At 1.30 P.M. the party gave a reception on the Pullman cars to distinguished Mexicans.

GEORGE LAY, a native of York, Pa., eighty-two years of age and the oldest locomotive engineer in America, having run the first engine on the Baltimore and Ohio Railroad in 1832, was recently drowned in White river, Indiana. He was residing with his son, and wandering away from home, it is thought accidentally fell into the river.

THOMAS J. BELL has been elected Superintendent of the Cincinnati Water Works, to succeed ARTHUR G. MOORE. The salary was reduced from $4,000 to $3,000, but as MR. MOORE held the double office of Superintendent and Engineer, the reduction will probably result in the creation of the office of engineer of the water-works.

Mr. Bell, who is said to be only 30 years of age, is the inventor of the well-known Bell Waterphone, and has been connected in various capacities with the water-works for the last ten years; he was Assistant Superintendent under MR. MOORE.

KOLTSI BAKAKI, an intelligent, well-educated Japanese, started for Tokio, May 16, carrying with him a trunkful of text-books and notes gathered principally in Philadelphia. The young man came to America 18 months ago, commissioned by the principal railroad company of Japan to study railway management in this country. He decided to acquaint himself with the details of the Pennsylvania Company's management, and, although only imperfectly acquainted with the English language, his progress is described as marvelous, and his politeness won him friends wherever he went. He spent several months in the Pennsylvania Company's general office studying the minute details of the business, mastering the system of accounts perfectly. He visited the company's shops at Altoona, and studied the mechanical features of railroading. In a short time, under KOITSI BAKAKI's direction, the clumsy English system of railroading now in use in Japan will give place to the system of the Pennsylvania Railroad Company.

OBITUARY.

COL. GEORGE M. TOTTEN, the well-known engineer, died at his residence, No. 13 East Thirty-second Street, on Saturday, 17th inst. He was born in 1809 in New Haven, Conn. He was graduated from Capt. Partridge's Military Academy at Middletown, Conn., and began his career as a civil engineer on the Farmington Canal, which is now part of the road-bed of the New Haven and Northampton Railroad. He then went to Pennslyvania and was there engaged on the Juniata Canal. In 1831 he became one of the engineers of the Delaware and Raritan Canal, in New Jersey, and in 1835 he was employed in building the railroad from Reading to Port Clinton. The following three years he spent in building railroads, first in Virginia and then in Pennsylvania, where he constructed the Sunbury and Danville Railroad. Subsequently he built the Gaston and Raleigh Railroad, in North Carolina, and in 1843 he was appointed Engineer in Chief of the Canal of Digue, that connects the Magdalena River with the harbor of Carthagena, in Colombia.

At the conclusion of this work John Trautwine and he took the contract for the construction of the Panama Railroad. In 1850 he was appointed Engineer-in-Chief of the work, and remained there for 25 years. Here he endured great sufferings and privations, being often compelled to work almost all day up to the neck in water, occasionally coming out to dry himself on some rock in the sun. The nights he spent on board an old vessel, where he was tortured by the myriads of ferocious musquitoes that infest the country. In 1879 M. de Lesseps invited him to accept a position on the commission that went to the isthmus to decide upon the canal project, and he was made chief of de Lesseps' staff. He was the only American engineer on that commission, which was composed of eminent French and Dutch engineers. Afterwards he went to Venezuela to survey a railroad, and later on he was appointed Consulting Engineer of the Panama Canal. As an engineer, Col. Totten was highly esteemed both at home and abroad, and he was frequently called upon by capitalists, who had full confidence in his ability and integrity, to decide upon the practicability of projected railroads or canals. He received many testimonials from foreign powers, among them a gold ring from Napoleon III., and a decoration and gold medal from President Guzman Blanco, of Venezuela. Age, hard work, and exposure finally undermined his strength, and a few weeks ago he suffered an attack of paralysis, from which he never rallied. He leaves behind him a widow and two daughters, one of whom is Mrs. George Putnam Smith.

Mechanical Engineers.

PITTSBURG, May 21.—At the meeting of the National Society of Mechanical Engineers this morning the following papers were read and discussed: "Heliacal Springs," John W. Cloud, Altoona, Pa.; "Estimates for Steam Users," Charles E. Emery, New York; "Rules for Conducting Boiler Tests," William Kent, New York; "Practical Solution of the Perfect Screw Problem," William A. Rogers, Cambridge, Mass., and "New York to Chicago in Seventeen Hours," W. Barnett Levan, Philadelphia.

American Society of Civil Engineers.

MAY 21, 1884.

The Society met at 8 P.M., Vice President William H. Paine in the chair. John Bogart Secretary.

A description of a Permanent Transmitting Dynamometer, constructed by the late Prof. Charles A. Smith, M. Am. Soc. C.E., was read. This dynamometer was put up in connection with the machine and engine rooms of the Manual Training School at St. Louis, and has been in constant use for seven years. Its peculiarity is simplicity, the tension of a belt being measured through a balance beam which compresses a spring.

The subject of temperature of water at various depths was discussed by Mr. D. J. Whittemore, President of the Society, who referred to the fact that cold water is frequently obtained by mariners upon the great lakes by sinking a corked jug to some depth, and then by withdrawing the cork the jug is filled with water very cold and refreshing.

Observations upon the temperature of the water at various depths in Pine Lake, Wisconsin, were also presented.

Temperature observations upon Lake Superior show comparatively constant temperature at the bottom of about 39 deg., and in depths from 400 to 100 ft.

Observations upon the temperatures of the earth, as shown by deep mines, were presented by Messrs. Hamilton Smith, Jr., and Edward B. Dorsey.

Mr. Smith said that the temperatures of the earth vary very greatly at different localities and in different geological formations. There are decided exceptions to the general law, that the temperature increased with the depth. At the New Almaden quicksilver mine in California, at a depth of about 600 ft., the temperature was very high—some 115 deg., but in the deepest part of the same mine, 1800 ft. below the surface, and 500 ft. below sea level, the temperature is very pleasant, probably less than 80 deg.

At the Eureka Mines in California, the air, 1200 ft. below the surface, appears nearly as cool as 100 ft. below the surface. The normal temperature of the earth at a depth of 50 or 60 ft. is probably near the mean annual temperature of the air at the particular place. At the Comstock Mines, some years since, the miners could remain but a few moments at a time on account of the heat. Some ice water was given them as an experiment; it produced no ill effects, but the men worked to much better advantage, and since that time ice water is furnished in all these mines and drank with apparently no bad results.

Mr. E. B. Dorsey said that the mines on the Comstock vein, Nevada, were exceptionally hot. At depths of 1500 to 2000 ft. the thermometer placed in a fresh drilled hole, will show 130 degrees.

Very large bodies of water have run for years at 155 deg., and smaller bodies at 170 deg. The temperature of the air is kept down to 110 deg. by forcing in fresh air cooled over ice.

Captain Wheeler, U. S. Engineers, estimated the heat extracted annually from Comstock by means of the water pumped out and cold air forced in, as equal to that generated by the combustion of 55,560 tons of anthracite coal, or 97,700 cords of wood. Observations were then given upon temperature at every 100 ft. in the Forman shaft of the Overman mine, running from 53 deg. at a depth of 100 ft. to 121 1/5 deg. at a depth of 2,300 ft. The temperature increased:

100 to 1,000 ft.	deep,	increase 1°	in 29 ft.
100 to 1,800 "	"	" 1°	in 30.5 "
100 to 2,300 "	"	" 1°	in 32.3 "

A table was presented, giving the temperatures of a large number of deep mines, tunnels and artesian wells. The two coolest mines or tunnels are in limestones, namely, Chanarcillo Mines and Mt. Cenis Tunnel, and the two hottest are in trachyte and the "coal measures," viz, the Comstock Mines in trachyte and the South Balgray in the "coal measures." Mr. Dorsey considered that experience showed that limestone was the coolest formation.

Mr. Theodore Cooper gave a description of a curious slide or slump which recently occurred near Dover, New Hampshire, a large section of a clay foundation having gone bodily into the adjacent river, moving trees with it, but leaving between the river and the cavity a bank of considerable width.

CORRESPONDENCE.

Correction.

CLEVELAND, O., May 19, 1884.

ED. ENGINEERING NEWS:—I see by a notice in your paper of the 17th that C. G. FORCE has been appointed City Civil Engineer of Cleveland, O., vice B. F. MORSE resigned. I did not resign. It was the end of my third term, or the end of nine years' continued service as City Civil Engineeer, and I failed to put in sufficient political work to get re-appointed; it turned out to be purely a political question. I was not, it seems, partisan enough for either republicans or democrats. Please correct the notice as far as the resignation is concerned. Very respectfully,

B. F. MORSE.

[From our personal acquaintance with MR. MORSE, we can appreciate the situation. A hard-working, competent and thoroughly conscientious engineer, MR MORSE belongs to that class of public servants who, endeavoring honestly to do their whole duty, have no time for political engineering. In the recent general "turn-over" of political parties in Ohio, so important an office as the City Engineership of Cleveland could hardly fail to excite an active partisan contest.—ED. ENG. NEWS.]

Memphis Sewers.

Special Correspondence Engineering News.

MEMPHIS, TENN., May 15, 1884.

EDITOR ENGINEERING NEWS:

Several persons have recently examined the sewers of this city and given their views to the public afterwards. Nearly all agree in pronouncing the operations of the system good, but generally find something to confirm their preconceived views.

First comes the statement that the Memphis sewers have been practically reconstructed, which I feel quite certain no person, having any knowledge of them, would confirm. Mr. G. W. Pearsons, of Kansas City, finds the system all that could be desired, but says much of the work was badly done. While I admit there are some places in which the work was not as good as it ought to be, I am confident that nothing in the experience of those in charge would justify so broad a statement as that of Mr. Pearsons.

Mr. R. Hering has a communication in ENGINEERING NEWS of January 26, which seems for the most part an argument against Col. Waring's patent rights. As I have but little knowledge of the patent laws, and no interest in the patent right, I have nothing to say as to this, but in the heat of argument and apparently influenced by what he on another occasion has called "a professional bias," he has presented some facts rather in a way to sustain his side of the argument than to give a correct idea of these sewers to your readers. He says the owners of some houses manage to turn either roof or yard water into them (the sewers) to an extent which increases their flow very materially during rains, and has compelled the building of special overflows from the sewers into the creek or bayou, etc.

Nearly all of the overflows that now exist were built while the sewers were in my charge and by my direction; not at all because of rain water in the pipes, but because, by an error in designing them, in not making sufficient allowance for waste, the 12 and 15 inch mains were made too small for the service and became overcharged during the waste of water in winter. It is quite possible that the authorities have become more remiss in the matter of rain water in consequence of the existence of these overflows, but previous experience has shown that by such supervision as could be given by two men, who did all of the work of sanitary inspection of the city, no inconvenience resulted from the admission of rain water.

He says also: "Stoppages have occurred to an extent which made it necessary to build man-holes every few hundred feet along the lines." The plain inference from this statement is, that the authorities are building man-holes every few hundred feet along the lines generally. Mr. Merriwether in answers to some interrogatories, printed in the *Sanitary Engineer* of March 20, says there are thirty-six man-holes on the mains and eight on the laterals. As there have never been any stoppages on the mains, these eight man-holes on about thirty miles of pipe must be Mr. Hering's warrant for his broad statement. While I do not agree with Mr. Hering in several of his conclusions, I propose only to notice further his last paragraph, in which he says: "Had not the man-holes and overflows been added, the system on the contrary would have given a good deal of trouble." Thirty-six man-holes on the mains and eight on the laterals and overflows from the two mains are then made to do duty as affecting a system of about thirty-five miles of sewers so as to prevent it from giving a good deal of trouble.

He further gives it as his opinion that the present successful operation is due to the abandonment of novel features and to the careful and intelligent management of Messrs. Merriwether, Ross, and Fisher. I do not desire to dissent from the careful and intelligent management, but is it not a merit of this system, in a sanitary view, that it cannot be neglected.

There being little surplus space in the pipes when any matter stops in them it almost at once imperatively calls for attention, and cannot be neglected as in what he calls a more liberal system.

J. H. HUMPHREYS.

LITERATURE.

Annual Report of the Chief Engineer of the Philadelphia Water Department for the year 1883.

The present report of Chief Engineer William Ludlow is voluminous and valuable in its contents, and vigorous in its language.

He first refers to the vain efforts of his predecessors in office to awaken the public to the necessity of a purer and more abundant water supply. Though for nine years past the urgent need of such improvement had been constantly laid before the community and different boards of experts had reported and made suggestions, no action whatever was taken in the matter; and the plant of the department itself was allowed to fall far behind the demands of the ervice, through lack of appropriations for extension. In 1882 the imminent prospect of a water famine again aroused public attention, and another Commission was appointed to report upon the best method of remedying the existing evils. The Commission made its report, but its recommendations awakened no response from Councils until April 1883, when the sum of $525,000 was made available for new works.

Mr. Ludlow came into office with the department in this impaired condition, and the coming summer threatening disaster.

The following statement gives in a condensed form the main additions made to the plant of the department within the year: A new and handsome engine and boiler house at the Spring Garden works, to contain two Worthington engines of a capacity of 15,000,000 gallons each, in 24 hours, to pump water into the proposed Cambria Basin, 165 ft. above City Datum, or into the East Park or Spring Garden Reservoirs, or directly into the distributing mains of the high level system. Ten steel boilers supply the power; they are of the marine tubular type, with Fox's corrugated furnace flues.

Electric light has been introduced at Belmont, and will be put into the Spring Garden Works; a new conduit is also being constructed at the latter works. A 7½ million gallon Worthington engine has been added to the Roxborough plant, and a 10 million gallon Corliss pumping engine has been contracted for at the Frankford Station; four new steel boilers, of the same type as those at the new Spring Garden Works, will be put in at Frankford.

The contracts for the above work were made with the following parties: Three pumping engines from H. R. Worthington, $117,000; one 10 million engine, of Robert Wetherill & Co., $44,000; twelve steel boilers, of 1551 sq. feet heating surface each, of the Edge Moor Iron Works, $77,330; the engine and boiler house at Spring Garden, built by Thomas Gamon, for $46,496; the Gloucester Works, R. D. Wood & Co., and A. H. McNeal furnished the specials used in making connections.

A thorough re-inspection of the whole city has been made. In making out the household water charges, in Philadelphia, the basis of

calculations is the number and character of the appliances in use, and the charge is made in accordance with a schedule of rates, irrespective of the amount of water taken or the number of occupants of the building. This plan is fairly satisfactory, but involves the serious disadvantage of domiciliary visits of inspectors. This annoyance to householders could be obviated by legislation which would enforce a notification to the Water Department of all alterations in plumbing. In the present case the number of properties examined was in excess of 160,000. The results, as far as reached, show an increase of revenue due this more rigid inspection.

The proposed new Cambria Basin, will cost about $500.000, exclusive of land, and its construction is only delayed by want of funds. The Chief Engineer recommends the employment of the inmates of the House of Correction upon this work.

The receipts of the Philadelphia Water Department for 1883 were $1,627,069.16, exceeding the receipts of 1882 by $110,000; taking into consideration the expenditures, which were much larger than usual, the gross profit for the year's business was $579,842.14. A further increase of about $233,000 is expected for 1884, owing to the re-inspection of household appliances.

A general statement shows that the total collections of the department, from 1855 to 1882 inclusive, amounted to $25,343,252.08, and the total expenditures for the same period was $17,190,896.00, making the surplus revenue for the 28 years exceed $8,000,000; and for the last eleven years there has been an annual average surplus of over $550,000.

With the substantial addition of the new pumping plant, now under construction, the Department will be able to pump a daily average of 90,000,000 gallons. But leaving out of the question the quality of the water, the most serious defects of the present system are found in the absence of adequate storage capacity, and the lack of proper means to distribute the water. The construction of the Cambria Basin, and the utilization of the East Park Reservoir will remedy the lack of storage for the present, at a cost of $2,000,000.

The distribution system is very defective, suffering chiefly from the common complaint of a demand which has far outgrown the small pipes originally laid. This state of affairs is especially noticeable in the Philadelphia of to-day, which is made up of the consolidation of the original city and a number of outlying districts, each of which at one time had its individual water supply, built without reference to a common system. In the old city proper, there are now 490,000 feet of water pipe, and 30 per cent. of this is made up of pipes under 6 in. diameter, and 90 per cent. has been in the ground from 30 to 60 years, and is of course seriously obstructed by rust. This is a dangerous and alarming condition of affairs in that part of the city where the wealth and population is most concentrated. In a section including only about one third of the total area of the old city, it is estimated that not less than $100,000,000 of active merchandise is exposed to risk from fire, and the value for the total area is $250,000,000.

In referring to the quality of the present supply, the Chief Engineer condemns the Kensington supply, from the Delaware River, as unfit for human consumption, and the Frankford supply as not being above suspicion. The condition of the Schuykill supply is the most important; this river is the natural sewer for a population of 350,000, largely engaged in manufacturing, and the character of the pollution is as diversified as the occupations of the people. An intercepting sewer, now building, will in a measure remedy this defect, but will not prevent the contamination from above the city. Filtering the water will avail nothing except to make it more pleasing to the eye, the really dangerous organic impurities will still remain chemically united with the sparkling fluid. Artesian wells have been frequently suggested, but the task of sucking 200 millions daily from the earth is no light one, and there is always the danger of pollution and uncertainty as to the future. The only practical and radical solution, according to the report, for the question of future supply, is to draw the water from a source which can be traced and protected ,from the mountain top to the city.

In speaking of the waste of water, the report states that the total pumpage for 1883 was 25,182,775,641 gallons, a daily average of 69,000,000, or nearly 70 gallons per head per day. Of this quantity the Chief Engineer estimated that 40 gallons is used and 30 gallons wasted. To ascertain the cause and amount of this waste, the Bell Waterphone has been tried with the result of detecting a daily waste, in the 12,000 inspections, of 2,740,000 gallons; as the 12,000 stops examined make up only one fifteenth of the total number, the total waste may be nearly 26,000,000 gallons per day, assuming the actual waste at only one-half of that reported, so as to be within the probabilities.

Without counting the interest on the plant, the average cost, to the city from 1854 to 1882, of pumping and distributing 1,000 gallons of water has been $4\frac{78}{100}$ cents; for the period 1872–1883, during which the pumpage increased while the outlay for improvement was injudiciously restricted, the cost was $4\frac{33}{100}$ cents per thousand gallons. These figures are based on the actual outlay for material and labor, including machinery, reservoirs, pipes, repairs, etc., since 1854, but do not include interest on the plant, nor upon the $6,500,000 of Water Loans. Taking the plant at an estimated cost of $15,000,000, and the interest at 4 per cent, and the interest on the loan at 5 per cent., it is found that $1\frac{32}{100}$ cents must be added to the above amount, making the total cost to the city of delivering 1,000 gallons of water, $6\frac{1}{100}$ cents.

Chief Engineer Ludlow makes some remarks upon the selection and appointment of employés, not usually found in a municipal report, and which remarks will hardly be popular with the average politician, who regards a municipal department in the light of an asylum for his henchmen. The present chief believes that city business can be conducted on private business principles, but to practice this doctrine, he very properly states that the administration must be enabled to obtain and retain the services of skillful and conscientious men, who shall be uncontrolled by any other consideration than the advantage of the work they are engaged in. It is essential that every man should clearly understand that his retention and advancement depends solely upon the necessity for and the value of his services, and that no consideration foreign to the welfare of the department will avail to discharge or retain him. As a consequence of this vigorous and healthy policy, an applicant for employment in the Philadelphia Water Department must now submit an application, in his own handwriting, and in accordance with printed regulations, giving his age, occupation, previous employment, etc., and support this with testimonials as to his general character and qualifications. From these application thus filed, selections are made, and the applicant put on trial, if he fails to reach the standard, he is promptly discharged and another is sent for. The system is reported as working well.

Included in the present report, and forming a most interesting and valuable portion of its 372 pages, is the report upon the Surveys for Future Supply, by Rudolph Hering, C. E. Assistant in charge.

Mr. Hering has gone about his work with a full appreciation of the magnitude and importance of his task, and the result is an exhaustive report upon the field to be covered and the progress made. Commencing with a condensed statement of all previous examination, looking towards an increased water supply, he classifies the practical schemes for supply, under the general heads of gravity, gravity supplemented by pumping, and a supply entirely by pumping.

As illustrating the extent of territory requiring investigation, we condense from Mr. Hering's report a statement of the numerous possible sources of a future supply.

Under the heading of Gravity-supply, that from the *Delaware Water Gap* comes first, but its distance, 80 miles, and the want of completed surveys, make the scheme an expensive one and as yet uncertain in cost. The excellence and abundance of the water is undoubted.

The *Upper Schuylkill* is too much contaminated with sulphuric acid from the coal districts to be considered at present.

The *Upper Lehigh* at White Haven, is 100 miles from the city, but from its unusual adaptation of water-shed, freedom from mining, farming or manufacture, geological features and high elevation, it is worthy of attention. It is only valuable, however, for future consideration, in connection with other projects.

The *Perkiomen Creek* has heretofore received the most attention, as being nearest to the city, but a thorough survey and examination is yet required to settle the mooted question of quality and quantity of its available supply.

The *Neshaminy* and *Tohickon Creeks* have not been heretofore considered, nor are they sufficient in themselves, but from their location they may be made valuable in connection with a scheme to be touched upon under the next heading.

Under the heading of Gravity, supplemented by Pumping, we have first:—The *Delaware River at Scudder's Falls*; this scheme was considered by the Commission of Experts of 1875, but its cost makes it at present inexpedient.

The *Delaware River at New Hope*, embodies two projects, also considered by the Commission of 1875.

The *Delaware River at Point Pleasant*. Above this location the Delaware River falls 15 feet in 2 miles, furnishing a considerable water-power, it is also at the mouth of Tohickon Creek, and on the only practical conduit line to the Delaware Water Gap. A high level conduit could be built from this point, therefore, to deliver water at the city reservoirs by gravity, which would possess the advantage of intercepting and carrying the waters of the Neshaminy and Tohickon Water-sheds; any deficiency could be supplied by pumping by steam or water-power, from the Delaware River, and at a point where the water is abundant and exceptionally pure.

A supply obtained solely by pumping, would contemplate the use of water from within the city limits. As artesian wells are the only source for such a supply other than the Delaware or Schuylkill Rivers, it is extremely doubtful if anything like a sufficient amount could be obtained.

Mr. Hering continues his report by a detailed statement of the progress made in the topographical work, giving methods and results as far as ascertained; the hydrographic work, which had for its purpose the investigation of the flow of the streams and rain fall; and the sanitary survey of the Schuylkill valley; this last is a new departure, and comprised an inspection of the water-shed for the purpose of ascertaining the various elements contributing to the pollution of the Schuylkill water. The report gives the quantity of domestic waste water and the disposition of the sewage and excrementious matter; manufactory waste was also stated wherever it could be ascertained.

A geological investigation was also made into the general features of the water-sheds

and the conduit lines. The total area to be investigated by Mr. Hering and his party will require careful surveys of about 468 sq. miles, conduit lines about 183 miles, and a general examination of about 6,500 sq. miles. While a great deal of this work has been accomplished in this first season's survey, much yet remains to be done before all the available sources can be studied and properly reported upon.

Albert R. Leeds, Ph. D., submits a preliminary report on the chemical investigation into the present and proposed future water supply of Philadelphia. It is a careful and detailed statement of methods of investigation adopted, and results, as far as ascertained.

Report of the Committee on the Metric System of Weights and Measures, Presented at the Annual Meeting of the Boston Society of Civil Engineers, March 19, 1884.

The committee report progress in their appointed duty of gathering all attainable information relative to the introduction of the metric system into the United States and the world at large.

The tendency of the present day is towards uniformity, as nations are drawn more closely together by mutual interest in matters scientific, commercial, political, statistical, literary, religious and charitable.

The committee refer to the recent adoption of standard time, and to the striving after uniformity in railway rolling-stock; in the latter connection the diversity of screw-threads is especially noted.

In Great Britain, the London *Graphic* is quoted as referring to the adoption of the meridian of Greenwich by the International Geodetic Conference at Rome, as a bait for the acceptance, by England, of the metrical system of the Convention of 1875. The *Graphic* admits that England has stuck in an old-world rut and that her insular system of coinage, etc., has been really detrimental to her continental trade. Sir Wm. Thomson and W. H. Preece, F. R. S., both refer to the metric equivalent in papers and addresses; the first alluding to it as a something "to which all scientific and practical measurements are irresistibly drawn," and the second stating that "the exchange of apparatus between England and Continental countries is now so general that the adoption of the French metrical system is well worth consideration."

The committee of twelve of the British Association reported in August, 1882, and recommended the Whitworth form of screw-thread, but they were not unanimous on all the questions involved, and also presented the Swiss system of small threads, (which is given in full in the report of the Boston Committee.)

Reference is made to a late conflict of systems of screw-threads in the City of Mexico, where the Sellers form, which was adopted in the railway-shops, was called upon for use upon French iron-pipes with screw-points.

In the United States, the 15th edition of the United States Dispensatory, is noted as for the first time using metric equivalents throughout for the doses and other expressions of quantity. The use of the metric system in the assay offices and by mining engineers is now quoted as a general practice, and as being much less confusing than the expression of "ounces per ton," when both ounces and tons differ in different parts of the world.

The sum of imports and exports, of American commerce for the year ending June 30, 1881, is put down at $1,526,590,575; and the conclusion is drawn from the tabulated report, that 43 per cent. of the foreign commerce of the United States would be facilitated by the adoption of the metric system; and that in 39 per cent. this adoption would be inconvenient until Great Britain and her possesions entered into the system; the remaining 18 per cent. is of little consequence either way.

The date of putting into effect the law of the exclusive use of the metric system in Mexico, has been postponed two years. In the Argentine Republic the French system is popular and gaining ground rapidly.

In the absence of the chairman of the Boston Committee, in Europe, Mr. Frederick Brooks, of Boston, has written the greater portion of the report reviewed.

Eleventh Annual Report of the Lowell Mass. Water Board to the City Councils, Accompanied by the Reports of the City Engineer and of the Superintendent of Water-works to the Water Board, January 15, 1884.

The daily average pumpage for 1883, was 3,021,655 gallons. There has been 524$\frac{7}{100}$ gallons of water raised 167½ ft. high for each pound of coal consumed during the year.

The total number of water-takers is 13,800, and 73$\frac{53}{100}$ mile of mains are laid, the increase in the year being 3$\frac{75}{100}$ miles. The total net charges for water-rates during the year, after deducting all abatements, and the charge for service-pipe, have been $141,316.82. The net cost of the works, including interest on Water Loan to Jan. 1, 1884, is $2,350,179; the gross cost of works to same date is $3.571,462.84.

The cost of pumping one million gallons of water from the low to the high service reservoir has been about $11.48, which added to the cost of raising the same quantity into lower service reservoirs makes the total cost about $20.51.

Journal of the Association of Engineering Societies. Boston, St. Louis, Chicago, Cleveland. Vol. 3. No. 7. May, 1884.

The contents include papers on "The Efficiency of Compressed Air," by C. M. Woodward; "Engineering Photography," by D. C. Humphreys; "Photometric Tests," by Thos. D. Miller; and the proceedings of the Boston Society of Civil Engineers, including their annual report; the Engineers Club of St. Louis; the Western Society of Engineers, and the Civil Engineers Club of Cleveland.

The first paper presents the principles of compressed air in as simple and intelligible a form as possible; it is illustrated by diagrams showing the effect of its application under varying conditions. The paper on Engineering Photography is as novel as it is interesting and valuable of application. Mr. Humphreys enters into the chemistry of his subject, and describes the lenses, appliances and manipulation of the plates; he shows its value to the practicing engineer, and explains the little known system of surveying with the camera. The paper on Photometric Tests is also an interesting one; it describes and illustrates the Bunsen-Letheby 60 in. Bar Photometer, with Goodwin's Electrical Attachment, and the 60 in. plain Photometer. A table of tests of gas-burners is also given.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

B. J. JAMES R. CROES, M. AM. SOC. C. E. : M. INST. C. E.

(*Continued from page 248*)

DCXXXIX, SANDWICH, ILL.

Sandwich, Ill., in lat. 41° 40′ N., long. 88° 37 W., is built on level ground. Settled in 1833, it was incorporated a village in 1860, and a city in 1872. Water-works was built by the city in 1883, after plans of W. C. Brown, taking the supply from ground water. From a well 14 ft. in diameter, and 28 ft. deep, walled with brick laid in cement, and yielding 432,000 gallons daily, the water is pumped by a Worthington pump of 18½ in. steam, and 10½ in. water cylinder of 10 in. stroke, to an iron stand pipe 12 ft. in diameter and 100 ft. high, built on a masonry foundation 25 ft. in diameter at the base, and 15 ft. diameter at the top, and 9 ft. thick. The water is pumped directly into the mains in case of fire, giving a pressure of 125 pounds.

Distribution is by one mile of indestructible kalmene pipe of 8 to 6 in. diameter, with 13 fire hydrants and 5 gates. Service pipes are also of indestructible kalmene. The works have just been finished and the numbers of service connections is not given.

The population in 1880 was 2,352, it is now given as 3,000. The works have cost $13,000. The bonded debt is $13,000 at 6 per cent. Samuel Milten is fire marshal and W. L. Simmons mayor.

DCXL. CANTON, O.

Canton, Ohio, in lat. 40° 49′-45″ N., long. 81° 22′ W., the county seat of Stark County is on generally level ground on Nimishillen Creek. Settled in 1806, it is now incorporated a city. Water-works were built in 1869 by the city after plans of J. Z. Pillsbury, the supply being taken from a lake about 2½ miles from the city and from the West Branch of Nimishillen Creek; the former has an area of 150 acres and a water-shed of about 13 square miles, and the latter rises about 5 miles above the pumping station, and drains a gravel country. The principal supply is taken from the creek, from which it is pumped by a compound Worthington steam pump, having a capacity of 3,000,000 gallons daily, and also by a small Cameron pump, directly into the mains, maintaining an ordinary pressure of 50 lbs. From the lake the water is connected to the pumps by a 24 in. earthernware pipe 1½ miles in length. Cement lined pipe was first laid, but has proved so unsatisfactory that it has nearly all been relaid with cast-iron pipe of 15 to 4 in. diameter, with 140 fire hydrants, 1 meter and 1200 taps. Service pipes are of galvanized wrought-iron. The daily consumption in 1883 was 1,000,000 gallons. The population in 1880 was 12,258, it is now said to be 18,000. The works have cost $200,000. The expenses in 1883 were $7000, and the receipts $12,000. Three trustees manage the works. Peter Barlet is President of the board, and Paul Field Secretary.

DCXLI. BROOKVILLE, PA.

Brookville, Pennsylvania, in lat. 41° 9′ N., long. 79° 10 W., is on Red Bank Creek at the junction of North Fork and Sandy Lick Creeks, and is built on three hills, the surrounding country being very rough. Settled in 1830, it became an incorporated borough in 1831.

Water-works were built in 1883 by a private company, under the superintendence of W. D. J. Martin, the supply being taken from the North Fork Creek, which has a drainage area of about 30 square miles. The water is pumped by a Worthington pump of 14 in. steam, and 8½ in. water cylinder, and 10 in. stroke, through a wrought-iron force main of 7 in. diameter to two barrel shaped wooden tanks set on framework 4 ft. above the ground, and being 150 ft. above the main part of the town, each having a capacity of 50,000 gallons.

Distribution is by 1½ miles of cast-iron pipe of 8 to 4 in. diameter, with 10 fire hydrants, 8 gates and 9 taps. Service pipes are of lead. The town pays $25 yearly for each hydrant. The works went into operation late in the fall of 1883. The population, in 1880, was 2,136. The cost of the works has been $16,000. The capital stock of the company is $25,000; there is no bonded debt. S. J. Marlin is President, and W. D. J. Marlin Secretary and Superintendent.

WATER.

THE Water-works of Gonzales, Texas, are reported in working order. The public supply commencing May 14.

BILLS have just passed the Mass. Legislature for a further supply of water for Cambridge, and a Waltham water supply.

RED BANK, N. J., has appropriated $60,000 for a water supply for fire protection; the Water Commissioners are selecting a source of supply.

THE Northern Pacific Railroad are employing a large force of men at Windsor in the excavation of a ditch a mile in length, for the purpose of conducting water to supply the town from Little Lake in that vicinity.

CENTRALIA, Pa., May 15.—The reservoir of the Locust Mountain Water-works, near here, burst last night. Centralia's water supply was entirely cut off.

THE Fort Worth, Tex. Water Company has commenced suit against the suspended firm of Donnell, Lawson & Simson, of New York, for $18,000, alleged to be due on the sale of bonds.

GLOVERSVILLE, N. Y., reports its water-works as being for the first time on a self-sustaining basis. The total cost of the works has been, to date, $88,916.60; and the income for the year ending April 30, 1884, $14,265.29; a balance of $3,747, is left after paying expenses.

CHICAGO, Ill., awarded bids last week, for 15,000 tons of water pipe. The Lake Shore Foundry received the contract for 12 in. pipe at $29.50, and the remaining pipe was given to Shickle, Harrison & Howard, of St. Louis, at prices ranging from $27.89 to $32.50 per ton.

THE Aqueduct Commission on the 21st, approved forms of contracts to be made with the owners of lands through which the aqueduct will pass, and considered forms submitted by the Commissioner of Public Works for contracts for tunnels, shafts, etc. The latter were prepared after consultation with the Corporation Counsel, and set forth the terms and conditions to which the contractor must agree.

FOUNDATIONS for the New Gaskill Pumping Engine are ready at the Kansas City Water-works. The engine is of a capacity of 9 millions of gallons in 24 hours, with 400 feet lift, and is expected to be delivered soon. Mr. G. W. Pearsons, engineer, is also engineer of the Ouray Mining and Discovery Co., and will spend most of the summer in working a large gold placer in Colorado—dividing his time between Kansas City and the mountains.

THE *Boston Herald* has been investigating the late complaints against the new Tremont Water-meters, in that city. At the Globe Theatre the meter has a trick of stopping for a rest apparently and then starting again; a Crown Meter has been substituted for it. This particular meter was said to back the water, by the reversal of the current into a house which was nominally cut off from the main.

The *Herald* has investigated eight separate cases of complaint, so far and has found them all well founded. The house-holders effected unite in voting the machine an annoying failure, especially where the Tremont replaced the Worthington meters, which had been working all right for years.

AT a recent meeting of the Trustees of the Village of Hyde Park, Ill., the bids for the construction of a water-works crib to be placed at the end of the new tunnel, one mile from shore, off the foot of Sixty-eighth street, were opened and read. William H. Hean, a well known Submarine Engineer and Armour Diver, and K. P. Corbyn, Civil Engineer, both of Chicago, offered to do the work for the sum of $25,000, according to the plans and specifications, which included twenty feet of tunnel; Robinson & Miner for $45,000, and T. E. Courtney for $26,000. The bids were referred to the water commissioner.

THE Hackensack Improvement Commission, of the village of Hackensack, on Tuesday last, at a special meeting held for that purpose, granted a consent to the Hackensack Aqueduct Company to organize and lay pipes through the streets, to supply the village with water. The corporators of the new company are mainly the large stockholders of the Hackensack Water Company reorganized, whose branch works in Hackensack are to be sold to-day, under a decree of the Court of Chancery of New Jersey. The new company intend to enter into active competition with the purchasers of the company for the privilege of supplying the village.

SWAMPING THE WATER-WORKS.—That lynx-eyed friend and servant of the Commonwealth, Hon. H. P. Whitaker, has jumped upon the Covington Ky., Water-works in the person of its Treasurer, George H. Davison, with both feet, for failing to make a monthly report of its taxable property to the State Auditor for the years 1870, 1871, 1872, 1873, 1874, 1875, 1876, 1877, 1878, 1882, and 1883. The said Auditor's Agent, Whitaker, filed a motion in the Circuit Court recently, which was set later on, inquiring why the said Treasurer shall not be fined $1,000 for each of the above failures, as prescribed by law. There are 192 failures alleged, there being that many monthly reports due and not made, and the amount of the fines is consequently $192,000. We feel well assured that George will give Colonel Whitaker nine-tenths of the whole sum if the Colonel will find that much money in George's exchequer.—Cincinnati *Enquirer*.

NEWS OF THE WEEK.

Too Late for Classification.

FAYETTEVILLE, Ark., May 22.—The directors of the Pacific and Great Eastern Railroad Company have closed a contract with the St. Louis Railroad Construction and Land Company to build the entire road, a distance of 350 miles, from Cincinnati, Washington County, Ark., to the Eastern State Line. Work will begin before September 1. The route penetrates a tier of counties in northern Arkansas abounding in timber and minerals.

PITTSBURG, Pa., May 22.—A party of engineers are surveying for a railroad from Coalport, Clearfield County, to Cresson, Cambria County, which, it is said, will open up the largest bituminous coal field in the State.

Bridges, Tunnels, Etc.

THE work of rebuilding the western approach to South Street Bridge, Philadelphia, has not yet been commenced, although the contract was let to Conkling, Shields & Co., some months ago. It was to be finished in seven months.

THE Western States Construction Company, of Chicago, have been incorporated, with a capital stock of $10,000; incorporators, Henry V. Pierpont, Willis I. Hitt, and John M Jackson. The object of the corporation is to take contracts for the construction of railroads and bridges.

THE contract for building the bridge for the Wisconsin Central extension, over the Mississippi River at Stillwater, has been let to the Union Bridge Company. The entire cost of the bridge, it is said, will be nearly $250,000.

THE Chicago, Burlington and Quincy shops, in Lincoln, Neb., are building a number of Howe-truss bridges for the new branch from Odell to Concordia. These bridges include one of 150 feet span, three of 125 feet, and several of 100 feet span.

SIX wholesale stores under the Brooklyn bridge are in operation. The stores are each two stories high, seventy-five ft. deep and twenty-one ft. wide. The average rent is nearly $2,000 a year. Other arches will be fitted up and ready for occupancy within a year.

YOUNGSTOWN, O., May 14.—The Morse Bridge Company, of this city, has been awarded the contract for placing an iron bridge over the Beaver River for the Cleveland and Pittsburg Railroad at Rochester, Penn., to supply the wooden structure swept away by the February floods. It will consist of three two hundred ft. spans, and cost $50,000.

BRIDGING THE ST. LAWRENCE.—Plans have been prepared for a new proposed bridge over the St. Lawrence at Quebec. The structure is of the Cantilever pattern, and has a total length from shore to shore, abutments included, of 3,100 ft. The centre span of 1,400 ft. consists of the two cantilever arms, 550 ft. each, and a rigid span in the centre of 300 ft. Each of the two shore spans is 550 ft. in length, making the total superstructure, 2,800 ft. long.

PORTSMOUTH, Ohio. May, 21.—This morning, soon after 11 o'clock, a crash was heard in the direction of the Sciota River, and an immense crowd soon gathered on the banks of the stream. The large suspension bridge, which was built about twenty years ago, became weakened and gave way, and several persons fell with it into the river. Mrs. Jane Fullwiller, with her three children, the youngest a babe of 4 months, were half way across the bridge at the time of the accident, and all four were drowned. Two young men were slightly injured, and three men saved themselves by swimming to the shore. The bridge was b ilt in 1893 at a cost of $40,000. It is a total wreck.

Contracting Miscellany.

AN ordinance has passed the Baltimore Councils, for the issue of bonds to the amount of $350,000, for the Harford Run Sewer.

THE plans for the new Court House at Pittsburg have been re-arranged to such an extent as to increase the probable cost of the building $350,000.

THE Mississippi has been shortened nine miles by a cut-off, two miles below Waterproof, La. The current is very rapid and the cut-off threatens to become the main channel.

THE contract for covering the steam-pipes at the Philadelphia post office has been awarded to Chalmer, Spence & Co., of Philadelphia.

BIRMINGHAM, Ala., May 19.—Sir Titus Salts and Charles Stead, of Soltaire, Eng.; William A. Donaldson, of Glasgow, Scotland, and J. T. Ferguson, of Dayton, Tenn., are here investigating the conditions for iron making.

THE Colorado Machinery Company of Denver, Colo. has failed, Liabilities $100,000. Among the principal creditors are the National Tube Works Company, of Boston.

THE sale of $60,000 sewer bonds of the city of Cleveland, O., has been interfered with by the financial panic. Good bids were received from New York and Boston, but they were withdrawn. The committee have decided to re-advertise.

THE Licking River is seeking a new mouth into the Ohio. The active agent seem to be a pier built about 8 years ago under the old suspension bridge, between Covington and Newport. The current, deflected by this pier, has been cutting away generous slices of real estate on the Covington side, and the damage was so great during the late flood, that with the vantage gained it is feared another flood will carry away a considerable portion of the city of Covington. Means of checking the threatened danger are being considered.

THE Commissioners Court awarded the contract to build the jail at San Saba, Tex., to Messrs, Starr & Co., of St. Louis, for the sum of $13,175. The competition in bidding was strong, and much feeling was exhibited by the different contractors. The stone and woodwork of the building will be done by Messrs. McKinna, Hogan & Robinson, of this place. Work will begin at once.

JUDGE BOND has filed an opinion in favor of the defendants in the case of the Union Railway Company against J. J. Dull and others, dissolving the injunction and dismissing the bill. The defendants were the contractors for the building of the Union tunnel in Baltimore, and the railway company filed a motion to set aside the award of $54,000 in favor of the defendants, made by the arbitrators to whom a matter in dispute was referred, on the ground that a witness, John Ellicott, an assistant to Engineer Martin on the works named, was interested in the award. Mr. Samuel Shoemaker, it was said, was to receive one-half of the profits of the contract, and promised Ellicott, in turn, one-half of his share. Mr. Shoemaker's share was about $13,000. Both he and Mr. Ellicott denied any collusion whatsoever, and the latter stated his testimony was in no way influenced by the promise of Mr. Shoemaker.

AT a meeting of the Central Park Commissioners N. Y. on the 21st, it was decided to complete the work on Morningside Park, and the architect was directed to prepare plans for that purpose. "The work has been dragging along for 10 or 11 years," said Commissioner Wales.

Engineer Van Winkle, of the Park Department, submitted plans for a tunnel under the Harlem River connecting with Jerome avenue, in the annexed district. The proposition is to build the tunnel by means of a coffer-dam. The approaches are to be open and descending by means of an easy grade to the tunnel. The crown of the tunnel is to be 20 feet below the bed of the river. The only land to be acquired is between Sedgwick avenue and One Hundred and Sixty-first street. The Commissioners viewed the plan with favor, as a solution of the difficulty of effecting a crossing of the Harlem River at that point. The law requires that bridges over the Harlem shall be built at right angles, while the avenues form an acute angle at the Harlem. Besides this the draw-bridge would seriously interfere with the passage of vessels up and down the river. The estimated cost of the tunnel is $1,500,000. It was decided to construct a driveway connecting Eighth avenue at One Hundred and Tenth street, with the main driveway in Central Park. A plaza is to be formed at the entrance similar to that at Eighth avenue and Fifty-ninth street. The drive will be about 1,500 feet in length, and will connect the main drive with Morningside Park. Thus a circuit will be formed through One Hundred and Twenty-second street to the Parkway and the Riverside Drive down to Seventy-second street. An artistic bridge will span the proposed drive near the entrance to the Park. A footpath will pass beneath the bridge. The expense of the scheme will be little more than the cost of the bridge.

Railroads and Canals.

THE Lehigh Coal and Navigation Company is probable the only one of the coal companies that has improved upon its last year's business.

J. A. MONTGOMERY, Division Engineer, Georgia Pacific R. R., with office at Bermingham, Ala., says that "Construction on the Georgia Pacific, will begin on June 1st. by the Contractors."

JOSEPH F. TUCKER'S RESIGNATION.—Joseph F. Tucker, traffic manager of the Illinois Central, will retire, in pursuance of a resignation tendered about a month ago. The resignation was to have taken effect May 1st, but out of courtesy to President Clark's request, he consented to remain until to-day. In Mr. Tucker's retirement the Illinois Central loses an official who is the peer of any traffic manager in the country, and whose twenty-eight years of service with the Central shows nothing but the cleanest, and most efficient administration. A prominent railroad manager remarked recently that Mr. Tucker's consistent fairness, straightforward action and the personal confidence he inspired in all managers with whom he come in contact had saved the company an almost incalculable amount of money. He had been instrumental in averting several wars of rates, and many times prevented the sacrificing of large revenues. Mr. Tucker has not decided which one of several flattering offers he will accept, but it is believed that he will become general traffic manager of a prominent Northwestern road. He will rest for several weeks before assuming new responsibilities.—Chicago *Times*.

SOME Nahant capitalists are agitating a railroad project to strike across from the island peninsula to the Eastern at the Point of Pines. The estimated cost is $175,000.

AN ordinance was laid before the Philadelphia Council for an elevated railway from Shoemaker town to Tacony, for passenger traffic only.

A RUMOR is that the Central Railroad company contemplates building a branch from Whitney to Waxahachie, Tex., at an early date, and that the road will also be extended from Terrell to Paris, to meet the St. Louis and San Francisco Railroad.

THE engineers who are making the preliminary survey for the proposed railroad from Fitchburg to Manchester, N. H., have run the line nearly to Milford, N. H., about 22 miles. The line, as far as surveyed, is quite feasible, and the road easy to build.

BOSTON, May 19.—The Cambria Iron-works Company, of Pennsylvania, has filed a bill in equity in the Supreme Court against the Cincinnati and St. Louis Railroad Company. The plaintiff alleges that the defendant road is indebted to it in the sum of $22,949 for steel rails.

THE Reading R. R. is discharging employés to the number of 500 within the last week. By the suspension of unnecessary work on the main-line, and the New Jersey Central, $150,000 can be saved per month. The resumption of mining will probably cause the reinstatement of many of the men dischargod.

THE bill for the construction of the elevated railroad, which is designed to run from the center to the extreme Western part of St. Louis and connect the northern and southern suburbs, passed the lower house of the municipal assembly May 12. The project is backed by some of the heaviest capitalists of New York.

THE Pennsylvania goes on steadily increasing the circle of its shareholders. Only a little while ago they numbered less than 17,000, now there are nearly 20,000 of them and the number has increased 1,300 since the November dividend. Ralli, of London, is still the largest individual stockholder, with 15,000 shares, and Mr. Thaw, with 11,175, comes next. Haseltine, Powell & Co. have about 86,000 shares registered in their names.

THE engineering corps of the Canton Company of Baltimore a few days ago began a survey of a line which is to run from Owings' Mills, on the Western Maryland Railroad, to a point at Canton a short distance below the elevators of the Northern Central Railway Company. The object in view is to offer to the Western Maryland road and its new connections, the Reading and other roads west and northwest of the Vanderbilt system, a better route and terminus. It is expected that the survey will be completed in about a month, and then the two companies will be in a position to open negotiations. When finished the line will be about twenty miles long.

URBANA, O., May 17.—The engineering corps of the Columbus, Fort Wayne and Western Railroad, in charge of Engineer Col. J. W. Andrews, which left Columbus on the 5th inst., reached Urbana last night. They touched West Jefferson, Mechanicsburg and Mutual, between Columbus and Urbana. Monday they will continue their work through Sidney, Berlin, and either St. Mary's Celina or Decatur, and thence to Fort Wayne. Along the route, the corps were cordially greeted and met no hindrances. They expect to reach Fort Wayne within 30 days. The road will be about 160 miles in length, and can be built for $15,000 to $18,000 per mile. East from Columbus the road will run to McConnellsville to intersect the Cincinnati, Wheeling and New York Railroad, which is already under contract.

PROGRESS OF THE SOUTH PENNSYLVANIA.—With the opening of the spring weather, work is progressing more rapidly along the line of the South Pennsylvania. The foundation for the first pier of the bridge, on the Harrisburg side, is completed. There will be 23 piers in the river, the one on the Cumberland side 60 feet high. An average of 10 feet a day is being taken out of one end of the Allegheny Tunnel. A dynamite factory has been erected here for the purpose of making explosives on the ground. A neat little locomotive has taken the place of mule power at the Laurel Hill Tunnel, where Patterson & Kuhn have a large force at work. Workmen have been underground at the Kittatinny Tunnel for some time. There was quite a furore over the breaking of ground on the sixth division, in Donegal, where Contractor Stanley has begun work on a section of three miles. There was a procession and some little speech making.—*Phila. Press.*

THE Elevated Short Route Railroad, connecting east and west Louisville via the river front, was formerly opened May 13, and the first train passed over. The road was built by C. R. Huntington at a cost of a million dollars.

UTICA, N. Y., May 18.—The contractors in charge of the erection of West Shore Railroad shops at Frankfort, work on which was suspended last December, have received instructions to resume work and complete the shop, foundry and boiler-house in six weeks. A large force will be put to work this week.

THE North Pacific R. R. is prospering according to the following report for March, 1884:—

	1884.	1883.	Inc.	Inc. p. c.
Earnings	$978,555	$567,903	$415,052	73.6
Expenses	542,279	481,740	60,538	12.6
Net earnings	$436,676	$82,162	$354,514	432.3
For eight months (July 1 to March 31):				
Earnings	$8,731,133	$5,575,445	$3,155,687	56.6
Expenses	5,500,350	3,609,314	1,891,044	52.5
Net earnings	$3,230,773	$1,966,130	$1,264,643	64.3

THE *Comercio*, of Bogota, announces that a company has been formed in New York, with a capital of $2,500,000, for the purpose of establishing train roads in the capital of Colombia.

An American citizen, Mr. William G. Boshell, has applied for permission to build a railroad from the Magdalena river to Bogota, passing by Bucaramanga, Piedescuesta, Sorocco, Velez, Chiquinbuira, Ubate and Cipaxuira. Mr. Boshell offers to furnish all the capital, in return for which he requires a privilege for 99 years and a grant of 300,000 hectares of land.

FARGO, May 13.—Track-laying on the Fargo Southern road will be completed between here and Wahpeton to-morrow. All the rails will be laid the entire length of the road, so that freight trains can be run by June 15. It is not likely that passenger trains will be put on until some time in July.

FARGO, Dak., May 13.—A committee of stockholders out to locate the route of the proposed Duluh, Fargo and Black Hills Railway, has returned, and reports progress. They found everybody enthusiastic over the scheme and willing to do everything in their power to help the road along. Property holders not only gave the right of way, but some of them offered to do some of the grading.

PHILADELPHIA, May 18.—The annual report of General Manager Charles E. Pugh, of the Pennsylvania Railroad Company, covering the operations of the main line between this city and Pittsburg, and branches, the United Railroads of the New Jersey Division, and the Philadelphia and Erie Division, for last year, shows that the gross earnings of the first-named division were $32,017,813, of which $24,536,789 was derived from freight, $5,987,625 from passengers, $465,265 from express, $484,352 from mails, and $541,780 from miscellaneous sources. The operating expenses were $18,321,413, leaving the net earnings $13,696,400. After deducting rentals for leased branches, the net profit was $12,008,460, an increase as compared with 1882 of $535,599. The total number of passengers carried over the main line and branches during the year was 10,697,474.

A NEW YORK Exchange gives the following gossip about the South Penn. R. R. It says that just before his departure for Europe Mr. Vanderbilt had a conference in New York with the leading Reading officials, at which he agreed to protect the Reading's Jersey Central stock, and to keep the Reading's own stock on the ragged edge of $20 a share until such time as the South Pennsylvania Railroad, which is to connect the Reading system at Harrisburg with the West, via Pittsburg, is completed, which will be about this time next year. He will then, it is asserted, take control of the whole Reading and South Pennsylvania system, and place it on a business basis. There will be a change in the Reading management. Mr. Vanderbilt has a high opinion of Mr. Gowen as a lawyer, and unquestioned faith in his honesty, and would back him any time as a fighter, but he believes a practical railroad man and not a lawyer should be at the head of a great corporation like the Reading Company. Leading stockholders, who are familiar with Mr. Vanderbilt's views and who have been consulted, say in case Mr. Vanderbilt does not own an actual majority of the stock by the time the South Pennsylvania Road is completed, that all the old Reading stockholders will gladly join him in putting practical railroad men in command.

It is stated in connection with the above that the Pennsylvania management recently made overtures to Mr. Vanderbilt that they would keep out of New England if he would give up the scheme of paralleling their main line with the South Pennsylvania. To this Mr. Vanderbilt is reported to have replied that while the offer was a tempting one it came too late.

THE manufacture of locomotives seems to be pretty lively, in spite of reports to the contrary. The Pennsylvania Railroad Company has lately ordered the construction of 137 more at the Altoona shops.

"I HEARD a very good anecdote a day or two ago from Chauncey Depew about Rutter, now the President of the New York Central Railroad," says an Eastern correspondent: "Commodore Vanderbilt picked Rutter up when he was acting as freight agent of the Erie Railroad. He was paid $15,000 to go over to the Central and take charge of their transportation business. Rutter was a slim young fellow with a ruddy face and prematurely gray mustache, and it is said he never got over being surprised with himself at his remarkable growth in the railroad business. There came up a decidedly knotty problem one day not long after he took hold of the Central's business. Rutter did not know what to do, so he walked into the Commodore's office and stated the case to the old gentleman. Said the Commodore: 'Jim, what does the railroad pay you?' 'Fifteen thousand a year, sir.' 'What for?' 'For taking charge of the transportation business.' 'Well, then, if we pay you for that, why do you come to me? Do you want me to earn your salary for you?' Rutter took the hint. He went right out, made a decision in the knotty problem, realizing that if he wasn't competent for the duties, the company would make short work with him, and if he was competent, it required difficult problems like that in question to show his competency. From that time until he became President of the great corporation he never asked anybody's advice about his actions. He did what he did, shouldered the responsibility, and expected to stand or fall by it. So that it happens that this man, who a few years ago was handling baggage and freight at an obscure station on the Erie Road, is now President of one of the greatest corporations in the world."

IRON, METAL AND COAL MARKETS.

PHILADELPHIA, May 22, 1884.

Prices are remarkable steady in all lines of iron, steel, hardware and iron products. No particular movement can be discovered, but there is a quiet, steady trade in progress which keeps capacity about three-quarters engaged. Quotations show not a particle of change, and buyers seem utterly indifferent as to the future of business. Really desirable grades of Foundry and Forge Iron are scarce, and good prices are readily obtained for such supplies as consumers want, but no more. No inducements can be made to draw out buyers. Merchant Bars are moving freely at 1¾@2c. but only for thirty to sixty days' requirements. Common iron sold to-day at 1.60. The prospects of a lockout in the West are favorable, a fact in which the East is interested. No large sales of Construction Iron or Steel Rails have been effected. Mills are fairly supplied with business, but the new winter business cannot be had now above $32.00. Iron and steel for engineering and bridge purposes are steady.

PITTSBURG, May 22, 1884.

Nails are $2.25 and active. The Syndicate has not been able to draw all members of the trade together. Considerable steel is being turned out for plates in place of iron heretofore used. A few days more will determine the fate of the mill people. Orders are not coming in freely, and good refined iron is in abundant supply at 1.70. There are several inquiries for Old Rails at $23@$24. Foundry Iron is dull but the better makes are held firmly. The production has fallen to 650 tons per day. Several furnaces are being repaired. The lockout, if it takes place, will extend into seventy rolling mills at least. Several inquiries are in hand for Bridge Iron. Steel Rail orders are backward.

CHICAGO, May 22, 1884.

The Northwestern iron markets continue active in certain lines, as, for instance, in material going into buildings, sheets, galvanized iron, pipes, tubes, fittings, boulders, hardware, copper, lead and tin plates; outside of these there is no change to note, but as is to be expected, great interest is felt in the probable outcome of the scale question. We feel safe in the Northwest for ninety days. No large Steel Rail orders have been placed.

COAL.

PHILADELPHIA, May 22, 1884

No improved movement can be noted in Anthracite Coal. Prices rule lower. There are additional rumors of a shut-down in June. Buyers are backward. New England holds back. Western orders are not numerous. Manufactory demand dull. Fall requirements will not be presented as soon as last year as the consumers believe there is something to be made by waiting. Soft Coal is active but week.